THE ENGINEER.

The Panama Canal.

By PERCY F. MARTIN, F.R.G.S., Special Commissioner to THE ENGINEER, 1910.

THE PANAMA CANAL.

To the practised writer and the experienced engineer alike, any serviceable description of the Panama Canal works as they stand to-day—a description, that is to say, which will serve to call to mind something approaching an accurate picture of the enterprise in all its immensity—must fall lamentably short of actualities.

The numerous attempts which have been made from time to time to afford the general public some sound idea of the gigantic task which has been taken in hand and the remarkable amount of progress which has been made have, for the most part, merely left the mind bewildered by the array of figures and computations dealing with distances, heights, quantities, and estimates, and which, after all, serve to convey but little that is retainable in the mind in the way of real information, and absolutely nothing of the marvellous detail of this vast enterprise.

It is eloquent of the immensity of the task which the engineers have set themselves to accomplish that, beyond, perhaps, one or two of the staff who have made a complete and exhaustive study of the colossal undertaking, few of those who spend their entire working hours on some part of the Canal have formed any concise or permanent idea of the operations as a whole. Plans there are in plenty, likewise maps, drawings, blue prints, and photographs galore; but the phase of construction which is depicted to-day may have possibly changed completely by to-morrow, so that no one can be said to possess definitely any realisation of what the works were or are, nor yet of what the enterprise will be in another three or four years' time.

It is small wonder that the Canal should so strongly appeal to the Americans, who love big things for their very bigness.

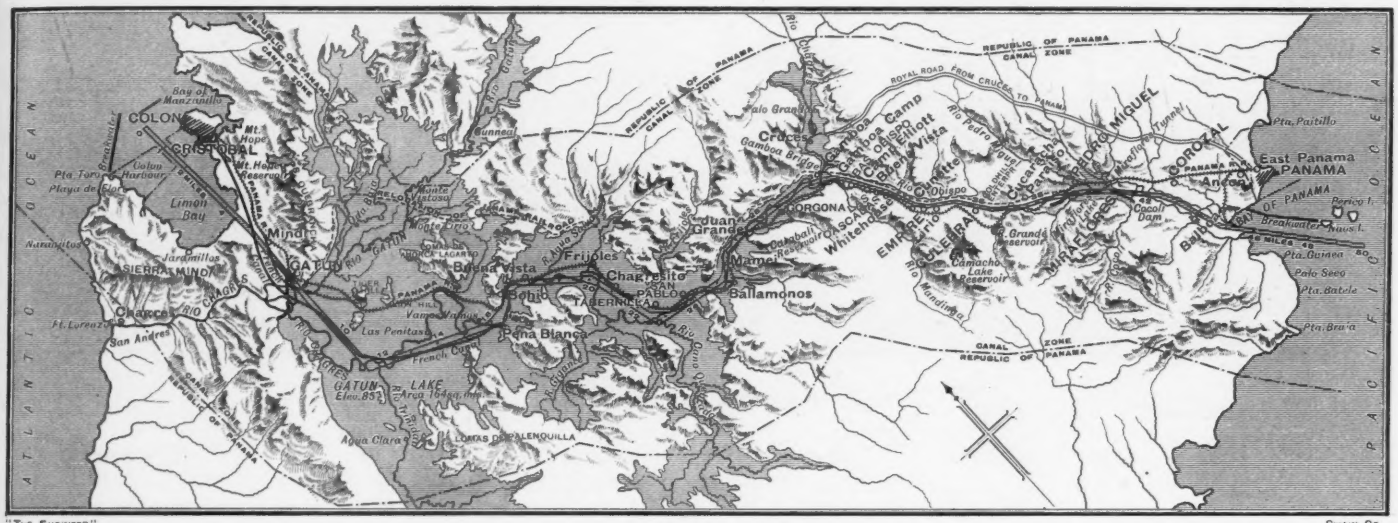
It may be advanced at the outset of a description of this work that the great secret of the success which has undoubtedly attended it is to be found in the admirable organisation, which is now, and has been for three years past, in force.

The work of the Canal has been divided into three administrative divisions known respectively as the Atlantic, the Central, and the Pacific; the first consisting of 7.7 miles, the second of 31.7 miles, and the third of 11 miles, or a total length, from deep water in the Atlantic to deep water in the Pacific, of about 50¼ miles, the length by land being 40½ miles—see Fig. 3.

To afford a brief mental picture of the Canal when completed, it should be remembered that in passing through it from the Atlantic to the Pacific—the distance of about 50¼ miles—see Fig. 1—a vessel will enter a channel with a bottom width of 500ft., in Limon Bay, and follow this for about seven miles to Gatun, when it will enter a series of three locks in flight, and be lifted 85ft. to the level of Gatun lake. The vessel will then sail at full ocean speed through this lake in a channel varying from 1000ft. to 500ft. in width, for a distance of about 24 miles, to Bas Obispo, where it will enter the Culebra Cut. After sailing through the Cut, a distance of about 9 miles, it will enter a channel with a bottom width of 300ft. on its way to Pedro Miguel. Here it will enter a lock and be lowered 30½ft. to a small lake, at an elevation of 54⅔ft.—see Fig. 2—above sea level, and it will sail through this for about 1½ miles to Miraflores. There it will enter two locks in series, and be lowered to sea level, passing out into the Pacific through a channel of about 8½ miles in length, with a bottom width of about 500ft.—see Fig. 3. The depth of the approach to the channel on the Atlantic side, where the tidal oscillation does not exceed 1½ft., will be 41ft. at mean tide, and on the Pacific side, where the maximum oscillation is 23ft., the depth will be 45ft. at mean tide.

The Atlantic Division extends from deep water in the Caribbean, and includes Gatun locks and dam; the Central Division extends from Gatun dam to Pedro Miguel locks, and the Pacific Division from Pedro Miguel locks to deep water in the Pacific.

For the purpose of this Supplement, I propose to take each Division separately, commencing with the Atlantic, which was the first that I had the privilege of visiting, and which, as already stated, is 7.7 miles in length.


ATLANTIC OCEAN
PACIFIC OCEAN
COLON
CRISTOBAL
Mt. Hope
Bay of Manzanillo
Limon Bay
Mindi
GATUN
SIERRA MADRE
Charco
San Andres
Gatun Dam
Gatun Locks
Gatun Lake
Bohio
Barbacoas
Frijoles
Chagres
Tabernilla
Peña Blanca
Ballamonos
Juan Grande
Mamei
Gorgona
Matachin
Obispo
Culebra
Cucaracha
Paraiso
Pedro Miguel
Miraflores
Corozal
East Panama
PANAMA
Balboa
Naos I.
Perico I.
Pta. Paitilla
Pta. Guinea
Pta. Brava
Pta. Garachine
Pta. Mala
Pta. Boruca
Pta. Burica
Pta. Mariato
Pta. Remedios
Pta. Piedra
Pta. Mosquito
Pta. Cocalito
Pta. Coiba
Pta. Hicaco
Pta. Jicaron
Pta. Montijo
Pta. Arenas

use of a goodly portion of it. The actual amount of excavation done by the French amounted to 78,146,960 cubic yards, and of that which has been found useful to the present Canal there have been 29,908,000 cubic yards. In addition to this, an immense number of buildings had been erected by the French company, a fact which may be appreciated when it is remembered that the Americans acquired from them 2150 buildings of various kinds, out of which 1537 have been placed in use. At the time they were transferred their estimated value was about 2,000,000 dols. (£400,000), but the Americans spent an additional 890,000 dols. (£178,000) in putting them into proper repair and adapting them to the requirements of their occupants.

Although there are great masses of old and disused French machinery still to be encountered on the Canal zone, it was not mainly "scrap" which the Americans took over from their predecessors. There are, for instance, thirteen of the original French locomotives still in use on construction work as stationary boilers, to furnish steam to various equipment. Four of these are at the dam and spillway at Gatun, and one on municipal engineering work at that place. Another is utilised for furnishing steam for the pumps in the excavation at Santa Cruz, and one is during the previous twelve months the material excavated in the dry amounted to 935,546 cubic yards, and in the wet 479,950 cubic yards.

At the beginning of March last the amounts excavated and remaining to be excavated in the Central Division were as follows :—

	Excavated. Cub. yds.	Remaining. Cub. yds
Culebra Cut	59,671,665	24,515,059
Chagres Section	11,361,357	1,576,437
	71,033,522	26,091,496

An immense amount of trouble and care has been expended by the engineers responsible upon the foundations for the locks. Various materials employed have been thoroughly tested in every way, and after being exposed to trial loads have shown conclusively that the soft sandstone has sufficient resistance to bear safely the greatest loads that will be brought on it by the structures now being erected. With regard to the curtain walls, it was decided finally to construct these so as to stop any underflow, and they will extend across the lock under the sill of the emergency dam and down-stream outside the lock walls to the sills of the intermediate gates. Serious age, the middle gallery for the wires which will carry the electric current to open and close the gates and work the valve machinery which will be installed in the centre wall, and the upper gallery will be a passageway for the workmen. The lock chambers will be filled and emptied through lateral culverts in the floors connecting with main culverts 18ft. in diameter in the walls, the water flowing in and out by gravity—see page vii. and Fig. 5.

Cement Supply.

The immense quantities of sand, stone and cement required for this work are brought up by barges by way of the French Canal to unloading docks, built on either side of the east diversion of the river Chagres, to which a channel has been dredged. The cement shed, having a capacity of 100,000 barrels, occupies the east dock, and is provided with a full equipment of electric cranes for unloading and storing the cement, very little manual work being necessary. Barges with sand and stone tie up to the west dock, and are unloaded with remarkable celerity by one single and two duplex cableways, supported by steel towers 800ft. apart, which transport the material to stock piles capable of storing about 200,000 cubic

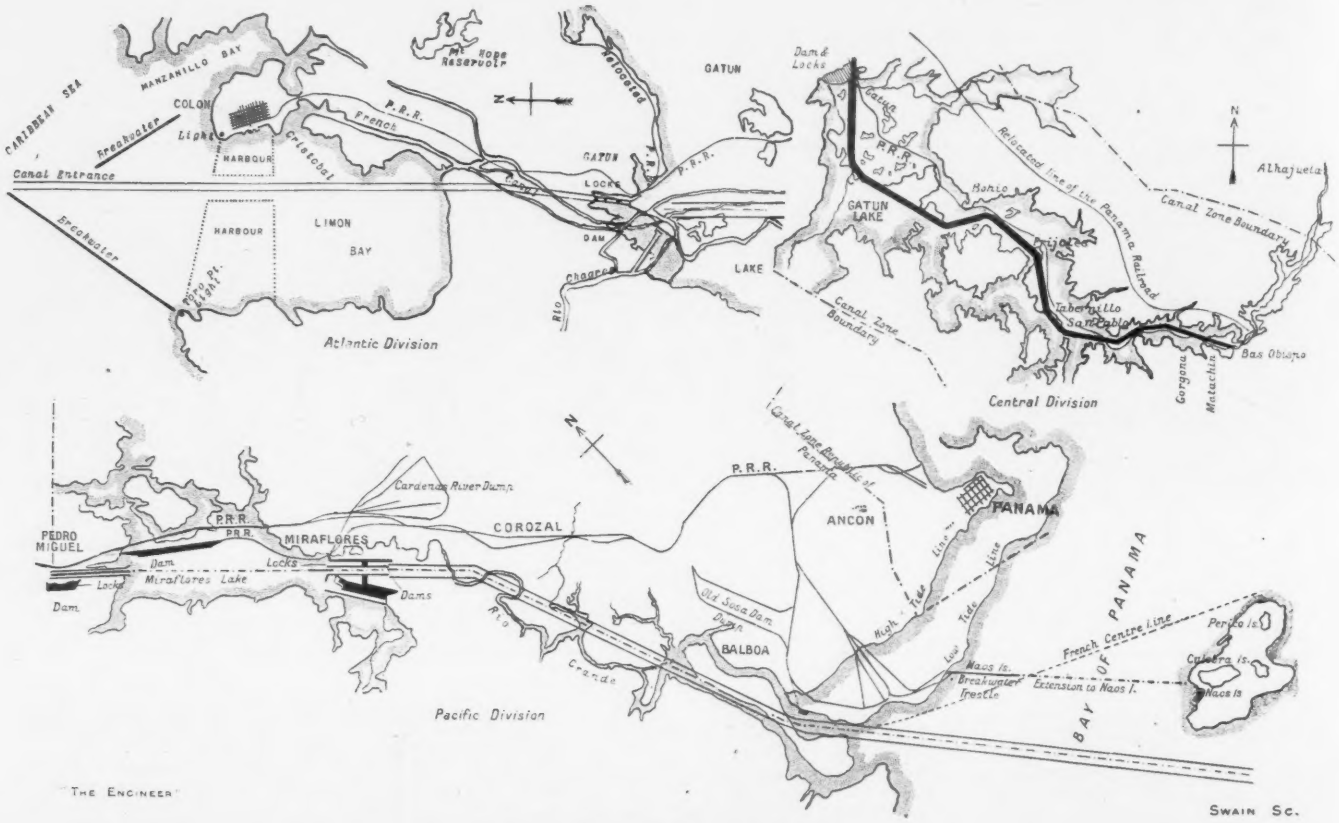


Fig. 3—PRINCIPAL FEATURES ON THE CANAL

in service at Gorgona. In the Pacific Division four are in service at Pedro Miguel locks, and two are held in reserve at Miraflores. These engines are in addition to those used as locomotives on construction work. There are also two truss spans of an old French bridge which was built across the Chagres River at Gamboa, and which have been in use since the Americans came into possession. They have now been taken down, and the parts painted and marked according to the erection drawings, so that they may be used again elsewhere. Both trusses are in good condition, and will answer well in any service where heavier equipment is not used. The larger is 204.3ft. long, and the smaller 102.5ft. long. This bridge was built by the old French company when it was preparing to construct a dam at Gamboa as part of the plan for a sea-level canal, the purpose being to haul the material across the river and up to the spillway on which work was in progress.

The work in the Atlantic Division comprises :—First, the construction of the Gatun locks and dam; secondly, the excavation of the channel between Gatun locks and the Atlantic Ocean, the construction of breakwaters in Colon Harbour, and the operation of docks and shops in Cristóbal; thirdly, municipal engineering, building construction, and zone roadways.

Gatun Locks and Dam.

There will be altogether twelve locks in the Canal, all in duplicate, viz., three pairs in flight at Gatun, with a combined lift of 85ft.; one pair at Pedro Miguel, with a lift of of 30½ft.; and two pairs at Miraflores, with a combined lift of 54⅛ft. at mean tide—see Fig. 4. The dimensions of all are the same, that is to say, usable length of 1000ft. and a usable width of 110ft. Each lock will be a chamber with walls and floor of concrete, and water-tight gates at each end—see pages vii., xi., and pictorial supplements.

Up till 1909 the greater part of the work had been devoted to excavation, a large number of steam shovels being employed throughout the forebay, but a yet larger number in the lock chambers, while a 20in. suction dredge had been used in the lower part of the lowest lock. At the time of my visit excavation was still going on, trenching for the curtain walls, and I understand that tests have also been made of the soft sandstone with regard to its holding qualities, such tests being the application of power to pull out French rails anchored into it by concrete. To carry out these tests as effectively as possible, a thickness of 13ft. to the concrete floor of the locks was given between the upper mitre sill and the sill for the intermediate gates, and old French rails on hand were utilised in the anchorages. I understand that the results have been in every way eminently satisfactory. An additional precaution has been taken by introducing a system of sumps under the floors, with tell-tales in the walls. In the forebay between the sill for the emergency dam and the first mitre sill of the lock, a 20ft. thickness of concrete has been adopted for the floor.

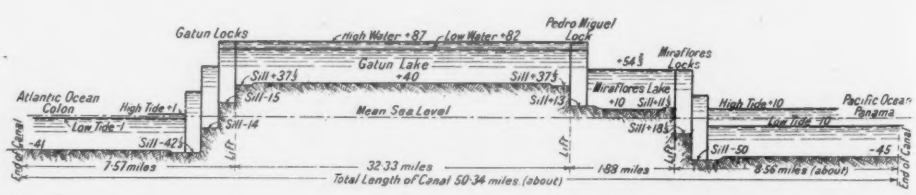


Fig. 4—DIAGRAM OF THE CANAL

The side walls for the three pairs of the Gatun locks, as well as for the three other pairs, will be 45ft. to 50ft. wide at the surface of the floor, will be perpendicular on the face, and will narrow from a point 24½ft. above the floor until they are 8ft. wide at the top. The middle wall will be 60ft. wide, approximately 81ft. high, and each face will be vertical. At a point 42½ft. above the surface of the floor, and 15ft. above the top of the middle culvert, this wall will divide into two parts, leaving a space down the centre much like the letter "U," which will be 19ft. wide at the bottom—see Fig. 5. In this centre space, which will be 44ft. wide at the top, will be a tunnel divided into three storeys or galleries. The lowest gallery will be for drainyards of stone and 100,000 cubic yards of sand—Fig. 7

To the ingenuity of the general management is due the installation of an electric railway, which passes under the cement shed above referred to, thence through tunnels under the stock piles to the concrete mixers built on the west side of the lock site. Automatic cars travel this road, and it is a matter of no small fascination to watch them coming and going with perfect regularity, as if endowed with human intelligence, and entirely unattended, while never failing to perform their allotted functions. Each car as it appears beneath the cement shed receives its allotted quota of cement in one compartment; it then passes a little further along and receives the proper proportion of sand; a little further yet, and its due assignment of stone is poured into a third receptacle, just sufficient of each material being apportioned to make a 2-yard batch of concrete. When fully loaded, and still unattended by any human being, the car starts off on its upward journey to the concrete mixers, where it is relieved of its load, again automatically, and despatched by another route to continue its useful and unceasing duties.

Cement Mixers.

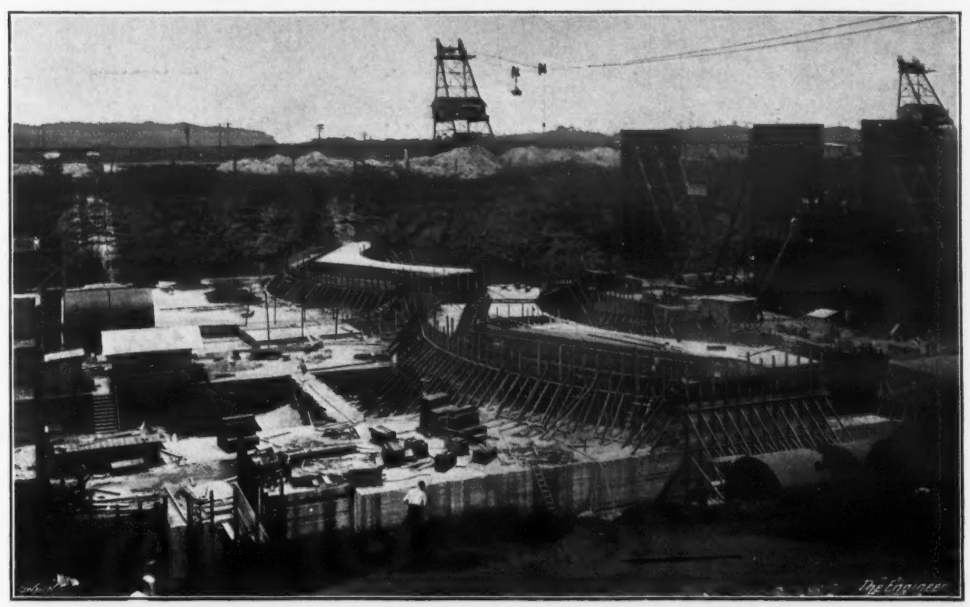
The mixers are of the cubical type, eight in number, and each dumping its product into a bucket on a car,

WORKS ON THE PANAMA CANAL

EXCAVATING FOREBAY, GATUN, LOOKING SOUTH FROM WEST WALL - DECEMBER 15th, 1909

THE SPILLWAY—APRIL 24th, 1910

GATUN UPPER LOCK FOREBAY, LOOKING SOUTH FROM WEST BANK—APRIL 30th, 1910



GATUN LOCKS—FOREBAY, SHOWING CONSTRUCTION OF UPPER GUARD GATE—MARCH 15th, 1910

two of such cars being taken by an electric locomotive to four duplex cableways—Fig. 6—800ft. across, which span the locks, and which, in turn, take the buckets and deliver the contents where desired. The entire plant is worked by electricity, with current supplied by three-phase 25-cycle alternating generators, each of 1500-kilowatt capacity, situated in a temporary power-house during the construction, but which house will eventually be—if not already—removed to a site on the spillway.

Locks.

Having seen how the lock chambers are being constructed, it will be interesting to know something of the general features of the locks themselves. The general condition imposed is that these locks shall pass vessels up to 1000ft. in length and 110ft. in breadth, and with a maximum draught of 40ft. in sea water. As a safeguard against accident, the upper lock at each lift is designed to have two sets of service gates—Fig. 13—at each end, and this, as well as the introduction of certain protective devices into the design, necessitates making the upper locks somewhat longer than the lower locks in each flight—see Fig. 9. The locks have twin chambers, each 110ft. wide, separated by a central wall. Measured from the hollow quoin of the lowest

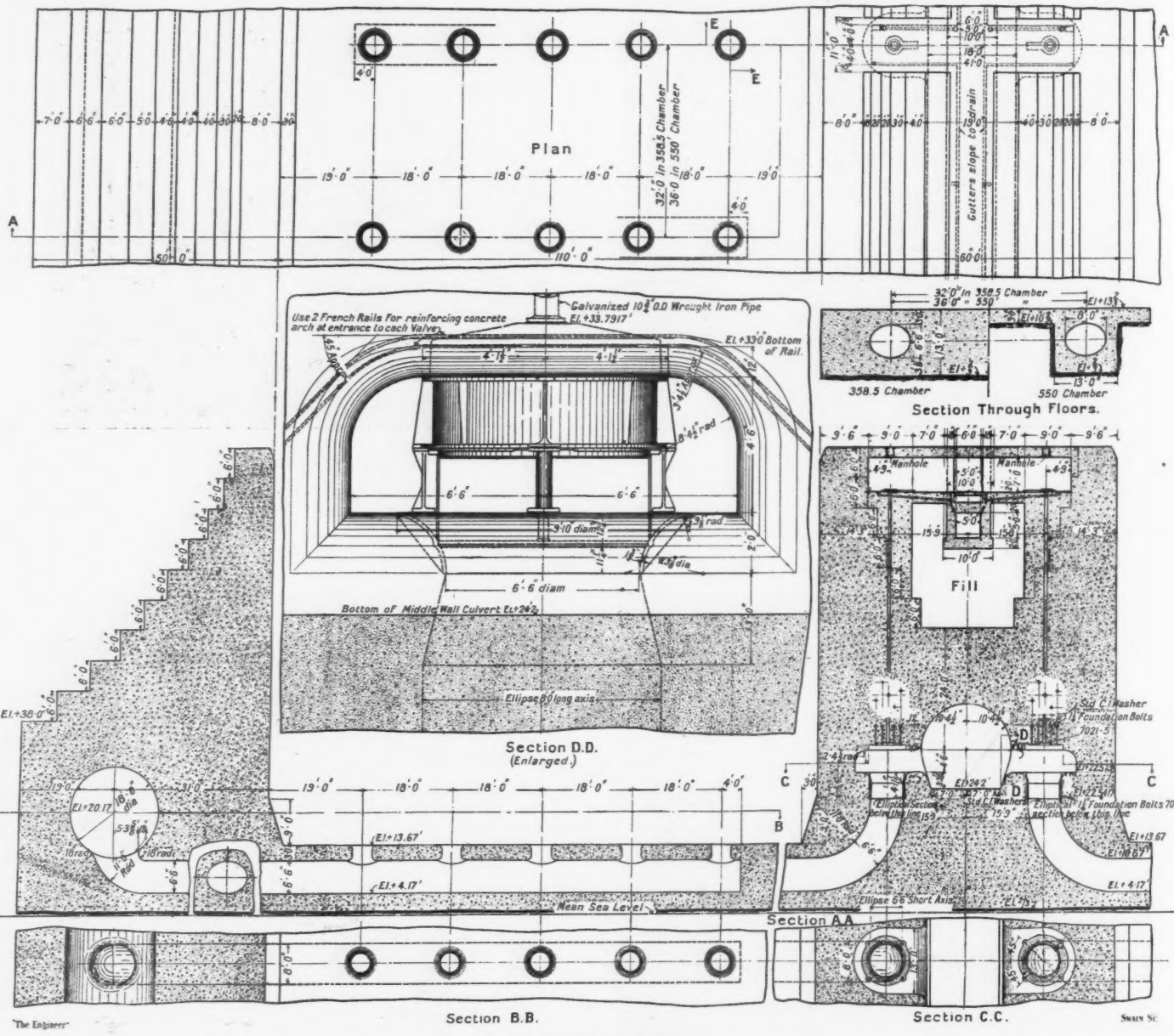


Fig. 5—SECTION OF LOCKS

set of gates to the hollow quoin of the set farthest up-stream, the length of the upper locks is 1181ft. The useful length of the lock, for a vessel passing downward, is assumed to lie between the protective chain guarding the lower gates and the hollow quoins of the upper service gates. Measured from this protective chain to the quoins of the lower set of upper gates, the clear distance is 908.5ft., and, measured to the quoins of the upper set of the upper gates, the clear distance is 1000ft. The sill for the upper set of upper gates is on the top of a lift wall separating the lock chamber from the forebay, and the gates are 54ft. 8in. in height above the sill. The sill for the lower set of upper gates is on the floor of the lock, and the gates are 77ft. to 79ft. in height above the sill, at Gatun and Pedro Miguel respectively.

In all lockages of vessels of 900ft. in length both sets of upper and lower gates will be operated simultaneously. In locking down-stream a vessel between 900ft. and 1000ft. long, both sets of lower gates will operate together, while the lowest set of upper gates will be left open, permitting the stern of the vessel to project in the space between the two sets of upper gates. In locking the largest vessels up-stream a similar advantage will be obtained by using the chamber between the two lower gates if required. The two sets of upper gates will be operated together. Thus it will be seen that the vessel will always have two gates in front of it separating the levels. The middle gate, with its hollow quoin 550ft. above the lower protective chain, will divide the lock into chambers of different lengths. The arrangement of valves and gates will be such that chambers of the length of 278.5ft., 370ft., 550ft., 908.5ft., and 1000ft. each may be utilised. The lower end of each flight will be provided with guard gates, in addition to one pair of service gates.

Emptying and Filling.

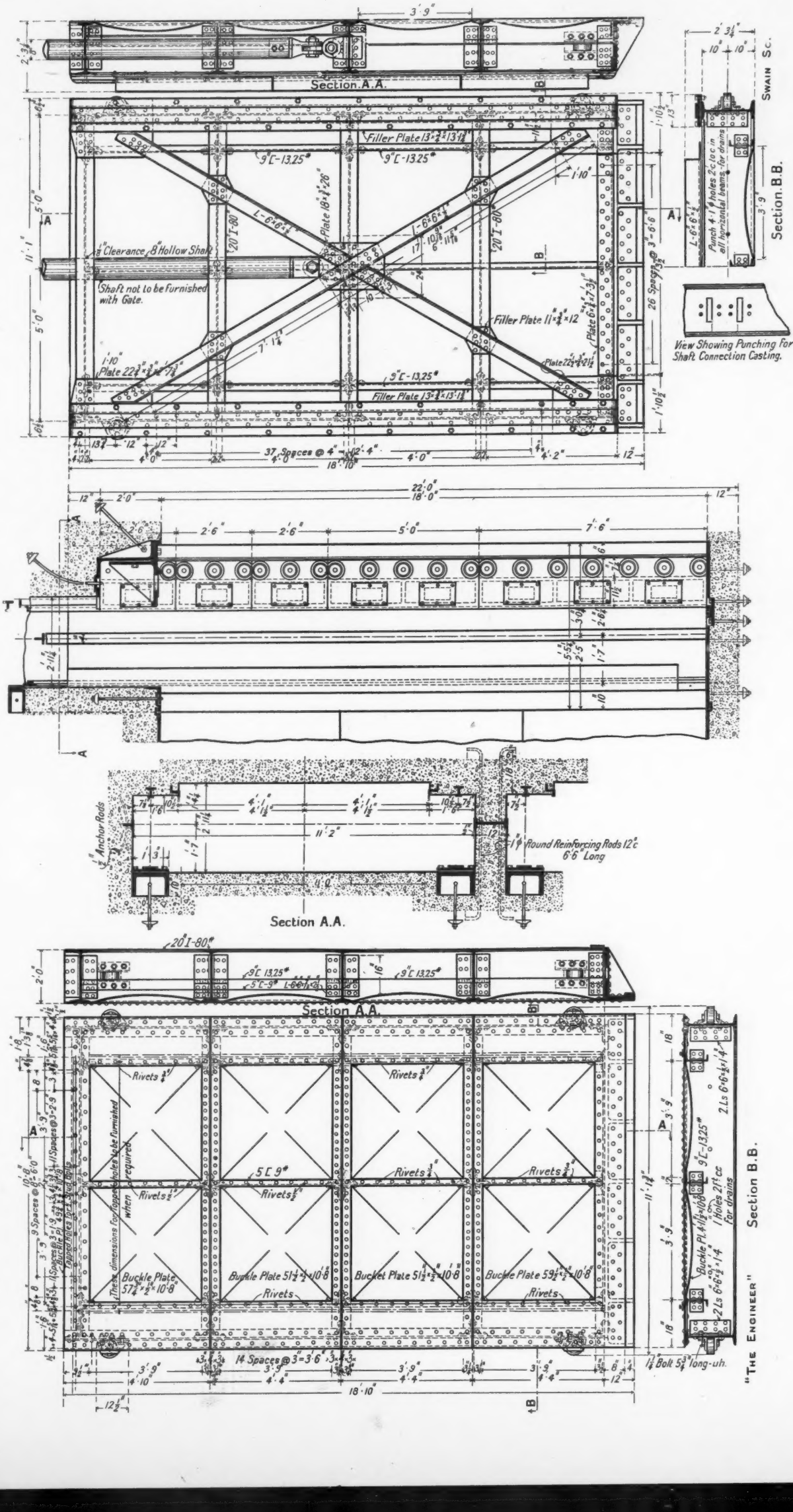
The design for filling and emptying the chambers has naturally been one of the questions which has exercised the minds of the engineers, and only after the most complete investigation and studies of different arrangements have the final plans been adopted. To fill and empty the chambers, culverts, running lengthwise to the lock through the base of the walls, are provided. Three such culverts exist, one in each side wall, and one in the middle wall, Fig. 5, each having a sectional area of 254 square feet, the equivalent of a circle 18ft. in diameter. Each of these longitudinal culverts will be controlled by rising stem-gate valves moving on frames of live rollers of a Stoney type. In the side wall culverts the intakes at the upper end of the wall will be provided with guard valves of this type, while the wall culverts will be provided with service valves at the upper, middle, and lower gates. At the point where the service valves are introduced the culverts will be divided into two parts by a middle pier, it being deemed undesirable to attempt to control the whole culvert by means of one valve. The valve at the lower gates is to be duplicated. Inasmuch as it is possible to use the guard valves at the upper ends, and one of the other of the duplicate service valves at the lower end of the lock, no interruption of communication need be occasioned by the failure of any one set of valves. The side-wall culverts will open directly into lateral culverts, of which there will be eleven on each side, each lateral culvert being 41 square feet in area. All of the lateral culverts will communicate with the chambers by openings through the floors, there being in each lateral five such openings, each with an area of 12 square feet. The middle wall culvert is to be controlled by duplicate sets of Stoney valves at its upper and lower extremeties. This culvert will communicate with the lock chambers on either side through lateral culverts, of which there will be ten similar to the side wall laterals, except that each one will be 33 square feet in area at the throat, and will be controlled by an individual valve at its junction with the main longitudinal culvert. This control is necessary in order that the twin lock chambers may be rendered independent of each other. The longitudinal culverts will extend the full length of each lock flight, being interrupted at the proper points by the Stoney valves. The same system of culverts will therefore be utilised both for filling and for emptying each lock.

The division of the locks into twin chambers by the central wall results in leaving two routes open, one for north and one for south-bound vessels. It is quite possible that when the Canal is in full operation each route will be reserved for vessels bound in one direction, except when one is temporarily delayed for purposes of examination or repairs.

Valves.

The main valves—page v., and Fig. 10—are designed to operate in a well moving on two trains of live rollers, spaced 10ft. centre to centre, and bearing on steel bed-plates fastened to the down-stream face of the well. The reaction on the separating pier between the two valves in each set will be taken on two steel plate girders embedded in the concrete pier. Each valve frame will be 18ft. 10in. high and 11ft. 1in. wide, and composed of 20in. 80 lb. I-beams and ½in. buckle plates, supported on the I-beams and on 9in. 13¼ lb. channels. At the bottom, in place of an I-beam, will be a steel casting, which will seat against a babbit-metal seal run in a groove in the floor casting. The buckle-plates will be on the up-stream face, and the frame braced by 6in. by 6in. by ½in. angles on the down-stream face. At each side of the frame there will be two rollers, which will bear against T-iron guides and castings. A special steel bearing plate is to be fastened on each side of the frame on the down-stream face, and bear against the roller trains. Running up each side on the up-stream face will be bronze springs—Fig. 12—which, when the valve is closed, will always be in contact with the wall castings, effecting a side seal against leakage. The seal across the top is to consist of a bracket fastened to a valve on the up-stream face containing a strip of rubber, which will seat against a bracket fastened to the roof of the culvert. All structural steel parts of

PANAMA CANAL—STONEY GATE VALVES



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these valves are specified to be of open-hearth steel, the I-beam and buckle plates to contain about 3½ per cent. nickel, and the rollers to be of tool steel.

Each valve will close a section of culvert 8ft. by 18ft., and during any operation it will move 18ft. vertically, and have a play of ¼in. up-stream, and a lateral play of ⅛in. either way from the central position. The valves

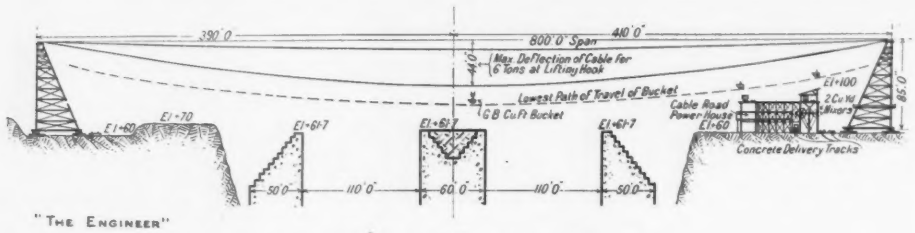


Fig. 6—CABLEWAYS OVER LOCKS AT GATUN

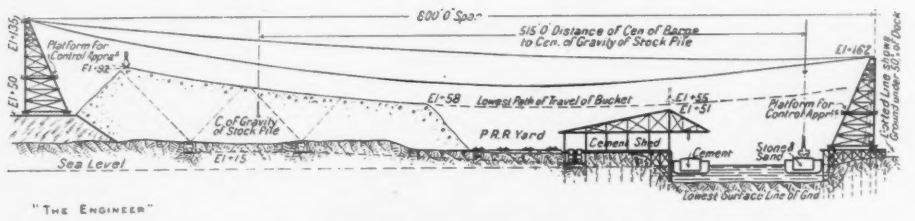


Fig. 7—UNLOADING CABLEWAYS AT GATUN

may be removed by lifting them up to the operating chamber near the top of the wall by means of the necessary operating machinery, and thence by lifting them out of the pit by cranes on top of the wall. They are to be connected near the centre to a stem, which will be worked electrically from the machinery pit. The time for raising the valves through the 18ft. is assumed to be one minute, and the weight of each valve, including stem and rollers, is estimated at 11 tons. The ordinary operating head against certain of the valves will be 60ft., and in certain cases they may be required to remain tight under a 76ft. head. To prevent water from the culverts getting to the machinery pits, which will be situated below high-pool level, bulkheads will be provided, in which stuffing-boxes will be fitted, through which the valve stems will pass. The cylindrical valves—Fig. 11—controlling the flow of water between the middle wall culvert and locks are to be placed in chambers opening directly from the culvert, 13ft. wide, 4ft. 6in. high, and about 14ft. long. The floor of the chamber will be raised above the floor of the culvert, and the lateral leading from it is to be about 6in. in diameter at the throat, but will increase to the elliptical section of the side wall culverts below the throat. The movable portion of the valve is to be a cast-steel cylinder 3ft. 3⅜in. high and 7ft. 1⅛in. in diameter, having four vertical webs radiating from the hub. It will have a vertical range of motion of 3ft. 1in. and a radial play of $\frac{1}{16}$in. from its central position. Moving on four guides, it may be drawn up into a stationary drum by means of a stem connected to the operating mechanism, which will be placed in pits at the top of the wall.

The maximum pressure to which these valves will be subjected is somewhat less than for the Stoney valves, but they will receive this pressure from either direction. Ordinarily they will work under a lower head, since it is intended, as already indicated above, to use the middle culvert only during the last five minutes of the lockage or when cross-filling. The valves will seat against a sectional iron casting firmly bolted to the concrete, and the upper seal will be effected by means of leather rings so arranged as to seal in either direction accordingly as the pressure is from within or without. The hollow stem and pipe in which the seal will work will be galvanised to prevent corrosion. The total weight of the moving parts of each valve is 22,500 lb. in air. The structural material

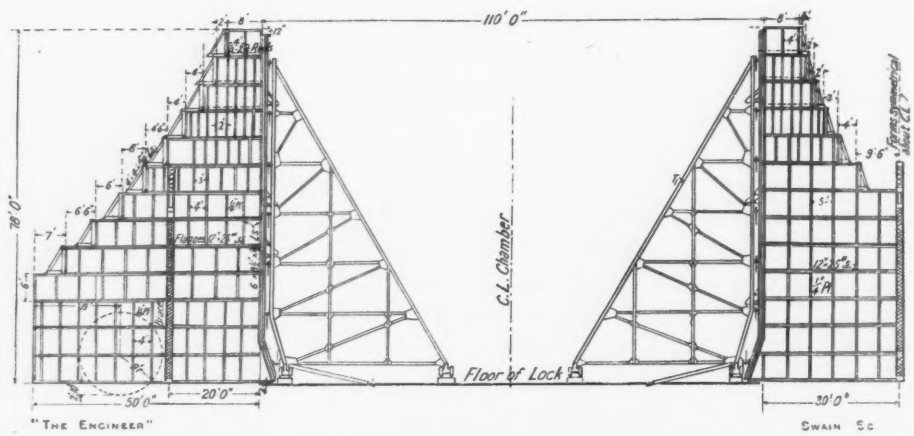


Fig. 8—FORMS FOR LOCK WALLS

to be employed is nickel steel, and the castings are to be mainly of steel.

Valve Tests.

Within the past few weeks tests have been carried out—but with what result, at time of going to press, I have not heard—with a Stoney-gate valve under full height of 85ft. of water, against which it will be obliged to operate when the canal is completed. The test has been made, I understand, by sealing up the culvert in which the gate is installed and filling the valve chamber. This should test the efficiency of the sealing devices and show the effect on the spring side seals when the gate is being operated, and the initial force which will be required to break the water seal and open the valves. In the spillway at Gatun dam three of the piers—there are altogether eleven of these in concrete—which have been built for cofferdam purpose, have been so constructed that the Stoney gate valves can be readily tested under working conditions.

Valve Machinery.

Such a comprehensive installation of valves naturally calls for special machinery to operate it, that is to say the Stoney gate valves and cylindrical valves in the locks at Gatun, Pedro Miguel and Miraflores. Altogether there will be required 116 machines, motors, and limit switches for operating the Stoney gate valves, and 120 machines, motors, and limit switches for operating the cylindrical valves.

The Stoney gate valves will be raised by means of two vertical revolving screws passing through two non-revolving nuts in the crosshead.

The 78in. cylindrical valves will also be raised by screw and nut. The motors for operating the machinery will be induction, totally enclosed, moisture-proof, squirrel-cage form, mill type, high torque, designed for 25-cycle, 220-volt system.

It is worthy of note that, in spite of the objection of the United States Government to entrust any portion of the Canal work to others than Americans, it has been necessary, in this case, to advertise for bids for the machinery required, such bids being asked for both in the United States and in Europe. For the information of readers of THE ENGINEER I may say that the time of delivery extends over a period of two years, in order that the material may be on hand when the completion of the successive parts of the concrete will permit of its erection. The type of lock gates employed throughout are illustrated by Fig. 13.

Excavation in Gatun Locks is practically completed, and all that remains to be accomplished is the removal of a small amount of material which had slid into the lower lock site from the east bank. On the north approach to the locks, however, excavation only commenced in the month of March last with a 20in. suction dredge, which digs to a depth of 45ft. below sea-level for the approach channel, and also digs foundations for the centre guide wall and the north-wing walls. The first shipment of material for the gates arrived on April 1st, and in the meantime, while awaiting it, a bridge was constructed and erected across the east lock of the upper flight, a second similar bridge having also been completed across the west lock. From these two bridges material for the gates will be lowered into place by means of locomotive cranes. It may be mentioned that even the bridges are moveable, and will be used for erecting all of the gates in due course. It is estimated that about 2,300,000 cubic yards of concrete are being used in these locks and spillway.

Old and New Gatun.

Many writers who deal with the Panama Canal dwell with most emphasis upon the Culebra Cut, probably because of its immensity, and, in their opinion, the great Gatun dam ranks as second in importance among the several remarkable projects which are comprised within

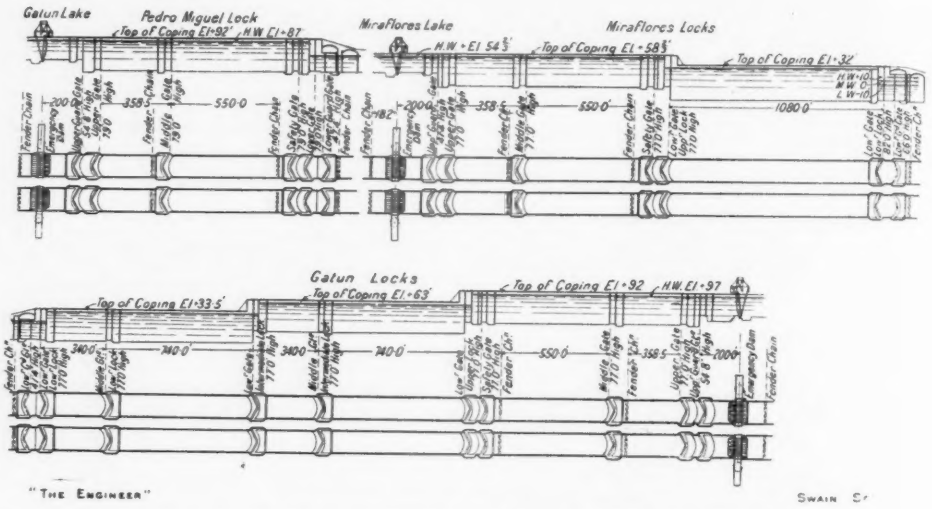


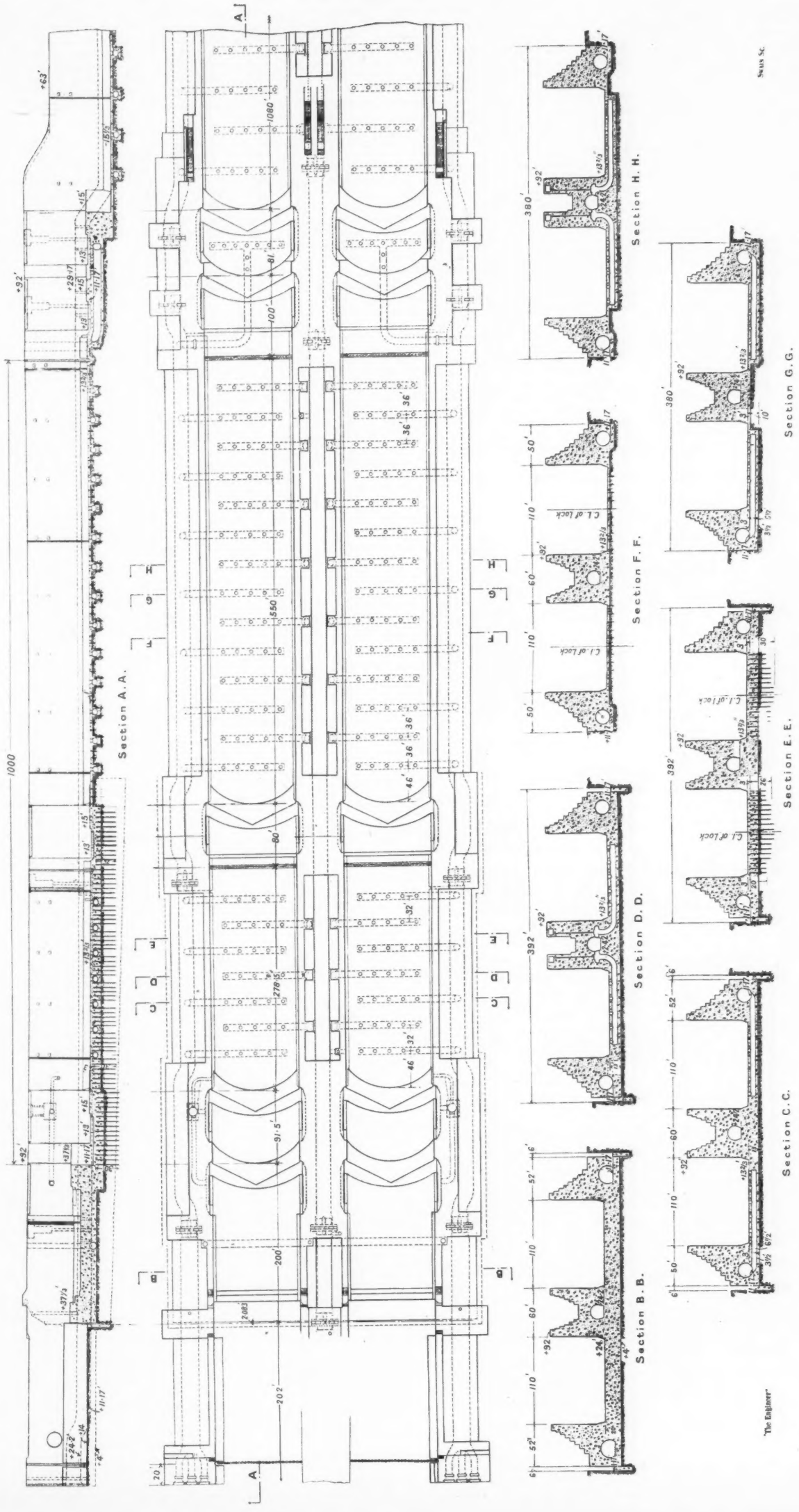
Fig. 9 GENERAL PLAN AND PROFILE OF LOCKS, SHOWING ALL GATES

the "canal works." And yet the "Cut," interesting as it is, can only be deemed "great" as regards actual dimensions, the operation itself being very ordinary, merely the cutting of a hill in two. Far different is the Gatun Dam, and next to that may be ranked the Spillway.

It was at Gatun that the French began operations in 1881, setting dredges and excavators at work and erecting a machine shop. A labourers' village was then established, with quarters for 500 men, and, later on, Gatun was made a residency. When the Americans came in 1904, Gatun was the centre of a comparatively large river trade, bananas and other produce coming there from the Gatun, the Trinidad, and the Chagres rivers for transhipment by rail. Now all traces of the old French settlement have been effaced, and the newcomers have erected many excellent edifices, some of which are likely to become permanent. The new town commands a view of the great dam and lock sites, and on the north it looks out toward Limon Bay, affording a glimpse of the shipping in the harbour and the dredging operations going on in the north entrance to the Canal. It is the typical American village, or rather town—that is to say, it is uniformly neat and clean, extremely plain and otherwise unattractive, and is ruled with that tyrannical orderliness peculiar to American settlements.

In the meantime, the dam itself is daily altering in appearance, and it is now quite a simple matter to perceive the progress made in construction. The east portion of the territory that is to be included in the dam is particularly noticeable on account of the progress of the hydraulic fill. The surface of the pond in the dam is rising perceptibly, while an army of labourers are stripping the top soil from the land to be covered by the fill. The south rock-toe has now been broadened until it makes a connection with Spillway Hill, and the north toe has also considerably broadened. The work already done in pumping from the borrow pits north of the dam shows that the Chagres River deposits sand almost as fast as the dredges pump it out. This sand, combined with the fine clay found south of the dam site, forms the best class

LOCKS—GENERAL TYPE



of material for the hydraulic fill. Pumping now goes on from both north and south sides, one of the methods found satisfactory in the experimental dams. The effect of this method is to deposit the coarser material along the toes of the dam, and to place the finer material along the axis, forming an impervious core.

Dam and Spillway Dimensions.

The main engineering features of the dam—Figs. 14 and 17—may thus be summarised:—Length, almost 1¼ miles; ½ mile wide at its base; 400ft. wide at the water surface; 100ft. wide at the top; with its crest the elevation will be 115ft. above mean sea levels, or 30ft. above the normal level of the lake.

The spillway—see Figs. 18, 19, and page iii.—will be 1200ft. long, 300ft. wide, cut through a fill of rock nearly in the centre of the dam, the bottom of the opening being 10ft. above sea level. The spillway is to be closed with a concrete dam—Fig. 19—fitted with gates and machinery for regulating the water level of the lake.

The type of dam now under construction is such as has been unanimously endorsed by the Commission of eminent engineers sent out by Mr. William B. Taft, when Secretary of State and President-Elect of the United States, to make a report upon the whole matter, but especially with regard to the dam. The names of these engineers are worth recording. They are:—Frederic P. Stears, Arthur P. Davis, Henry A. Allen, James D. Schuyler, Isham Randolph, John R. Freeman, and Allen Hazen. Even that severe critic, M. Bunau-Varilla will admit that this galaxy of engineering talent is dependable? Well, these gentlemen subscribed to the adjoined certificate:—"We are satisfied, both from the records of the experiments that have been made, and from our own personal examination of the materials, as seen in cuts now open and as disclosed by samples from test borings, that there will be no dangerous or objectionable seepage through the materials under the base of the dam; nor are they so soft as to be liable to be pushed aside by the weight of the proposed dam, so as to cause dangerous settlement. We are satisfied also that the materials available, and which it is proposed to use, are suitable, and can be readily placed to form a tight, stable, and permanent dam." This unequivocal assurance should sufficiently answer M. Bunau-Varilla's criticism as to its safety.

Gatun Dam Materials.

The Gatun dam—Fig. 17—it will be remembered, is a combination of rock-fill and hydraulic fill, in which the exterior faces are composed largely of rock of all sizes obtained from the canal excavation, dumped and laid upon slopes much flatter than are ordinarily found in earth dams, while the interior of this great mass consists of clayey material obtained by hydraulic dredging from deposits situated at a little distance from the dam, and which is being carried by water through pipes to the places where it is being used. As delivered, the material is a mixture of earth and water, which, held in suspension, slowly deposits, finally forming a solid watertight embankment. The pond, which has been formed and maintained of a necessity upon the top of the dam during construction, has tested the embankment at all stages of its growth, has searched out any weak spots, and has led to the closure of any voids or cracks.

Sand and Gravel Variations.

The canal engineers, in order to build a dam of these clayey materials which will prove stable and permanent, have made the slopes much flatter than would have been necessary to secure the stability of a dam of silicious, sandy or gravelly materials. They thoroughly examined and as carefully sifted all the evidence that could be collected as to the degrees of slopes that are stable with these materials, and they deemed such evidence to be conclusive. The fact that the materials are "slippery," in their opinion, does not necessarily mean that a dam built from them is, as a consequence, less stable than a dam built of materials that do not slip so easily. It does, however, mean that, in order to secure stability and permanency, the dam must be—as it is being—built with a greater thickness at the bottom. The dam, as a matter of fact, is more than a third of a mile in horizontal thickness at its base, including the rock-fill portions.

The design adopted, it is declared, abundantly fulfils the required degree of stability, and goes far beyond the limits of what would be regarded as sufficient and safe in any less important structure. M. Bunau-Varilla's denouncement of the dam, and his declaration that the slipping which has already taken place is a sufficient proof of the accuracy of his contention, is covered by the following assurance made by the United States Commission:—"As a matter of convenience and economy during construction, materials have been piled up much more steeply than was contemplated in the finished work. Generally the materials so placed have remained in position; but in some cases slips have occurred. The occurrence of these slips is of no serious consequence, either in the practical execution of the work or in the ultimate stability of the structures. We can readily understand how incorrect deductions may have been drawn from these occurrences, especially by those not fully informed as to the character of the materials and the ample dimensions, and much less steep slopes of the proposed structures, in their final form."

Dam Design Altered.

As to the design of the dam, to which M. Bunau-Varilla is also bitterly opposed, I may point out that in the original cross section the crest of the dam was placed at reference + 135, or 50ft. above normal lake level. Construction was actually commenced upon the design proposed by the Head of the Department of Lock and Dam Construction in 1907, in which the piles of stone constituting the toes of the dam were placed 1200ft. apart, and a row of sheet piling was to be driven through the surface layer along the axis of the dam. During 1908 two sections of the dam were prepared in the office of the division engineer o the Atlantic Division, and submitted for approval. In one case the crest reference was kept at + 135, and in the other it was reduced to + 105. This reduction in height to + 105, leaving the upper surface 20ft. above normal lake level, was strongly recommended. The Commissioners, however, decided upon a certain section of the dam, placing the reference of the crest at + 115, reducing the width of the impermeable material to be placed between the toes of the dam, and omitting the axial line of sheet piling. This section has been followed in the subsequent construction.

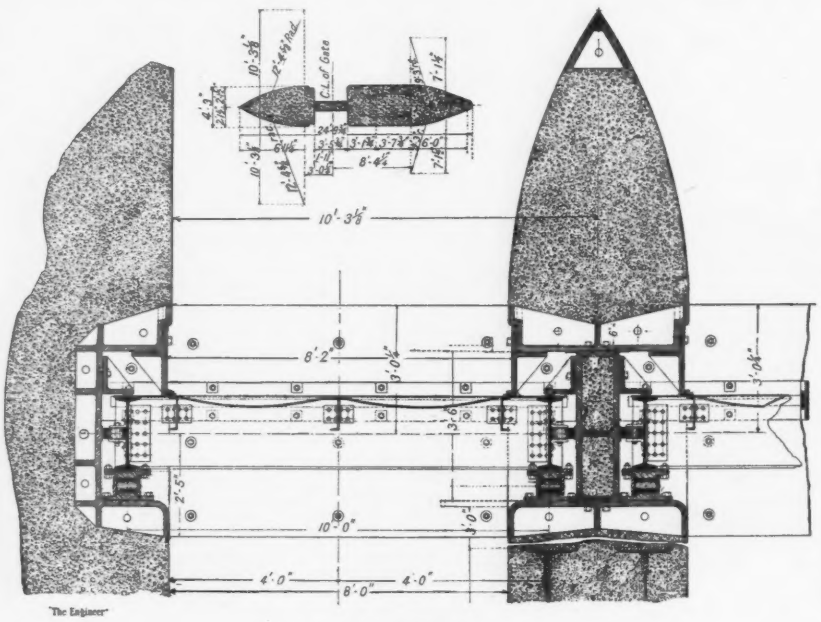


Fig. 10—STONEY VALVE

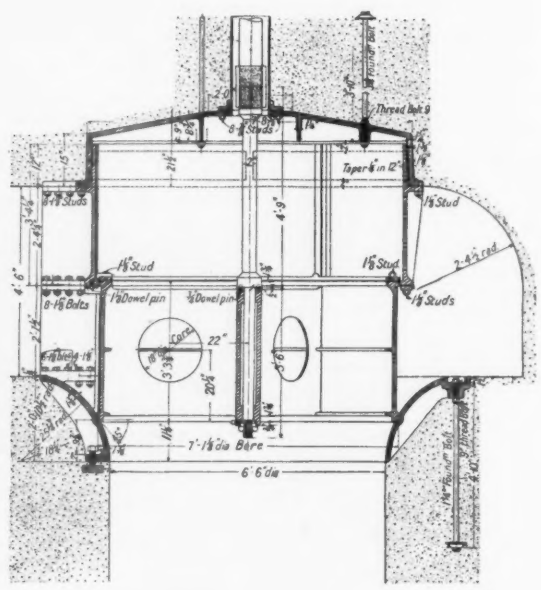


Fig. 11—CYLINDRICAL VALVE

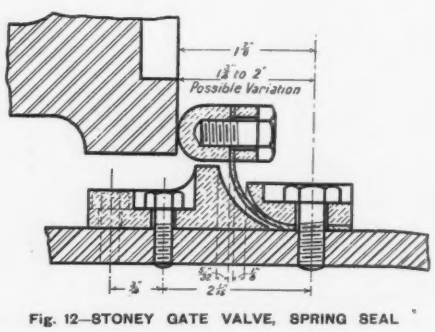


Fig. 12—STONEY GATE VALVE, SPRING SEAL

Lock versus Sea Level.

Intimate association with the official members of the Isthmian Canal works discloses the fact that there are among them several who still dispute the statement that the lock canal is the best that could have been adopted, and while they, for the most part, judiciously keep their opinions to themselves, they none the less continue to pin their faith to the superiority of the sea-level canal. Probably there never has been a question upon which engineers have been so hopelessly divided as this. The controversy has been raging now for five or six years, and the last word can only be said when the Canal has been opened and working for some few years. Even then we shall come across some of the controversialists upon one side or the other who will remain unconvinced.

Earthquake Dangers.

M. Bunau-Varilla is, of course, by no means the only critic who loudly proclaims disaster for the lock canal, but others are somewhat more convincing in their arguments, because they are more explicit, and not so bitterly hostile as is this engineer. I have already mentioned the circumstance that even upon the Isthmus itself, and within the ranks of the Commission's own servants, are to be found sceptics who take a despondent view of the Canal's stability and utility. They give their reasons, and among these are the following:—

In passing through the Canal ships will have to face the danger of an earthquake shock, which, if experienced, will render the Canal impassable. They also point to the serious disasters which have already occurred upon the Pacific Coast of South America, such as the destruction of Lima and Valparaiso, and they aver that "what has been may be again." While it would be absurd to deny this truism, it is as well to point out that, up till now, there has been no serious earthquake experienced at the Isthmus of Panama itself, which is situated just outside the earthquake zone. On the other hand, I have seen many evidences of the innocuousness of such "quakes" as have been experienced in the form of ruined buildings, not occasioned by seismic disturbances, however, which have stood for years in the same condition, though any serious trembling of the earth must of a necessity have brought them to the ground. I refer particularly to the overhanging walls of the San José Church at Panama, and the dilapidated walls of the Santo Domingo Convent, which have been standing in a ruined condition since the eighteenth century. In the latter ruin there is a flat arch over 23ft. high, which is a free structure, running across near the centre of the building, and entirely unsupported front or back. The thin overhanging wall of the San José Church, above referred to, is even a more convincing example of the weakness of the earth tremblings in this district, as the wall is only supported at its base by some crumbling brickwork.

Two high, unbraced gables, with numerous openings, which have weathered several centuries, are yet again testimony to the little real danger which threatens this part of the Pacific coast. However, it may be safely concluded that if an earthquake visited this country it would be as likely to cause havoc to a sea level as to a lock canal. Of this eventuality neither M. Bunau-Varilla nor his brother critics seem to take much notice. A tidal wave, or a sinking of the narrow spit of land which forms the Pacific side of the Isthmus, would be quite sufficient to ruin irretrievably any canal that man could devise; but if one is to be deterred from carrying out great engineering enterprises by such fears, and to pause upon the brink of works of this character for dread of what may—and still may never—happen, it would be useless to enter upon them at all.

Gatun Dam.

Although construction upon the Gatun Dam was begun only in 1907, an immense amount of work has been carried out, and progress has been so rapid that the engineers themselves have expressed their astonishment. The original cross section tentatively proposed for the dam was not adhered to, a change being made by building the slopes flatter and modifying in part the general dimensions. Work had actually been commenced when a board of expert engineers appointed by the present President of the United States visited Panama, and

expressed themselves as dissatisfied with the plans adopted. Among other recommendations which they made was one, as mentioned above, in connection with a certain section of the dam, placing the crest at + 115, reducing the width of the impermeable material to be placed between the toes of the dam, and omitting the axial line of sheet piling. This section has been followed in subsequent construction, and the design is to be found set forth in the plan of the maximum section.

Work Done.

Up to the time of my inspection the south rock fill, east of Spillway Hill, had been raised to a considerable elevation, exceeding + 60, while the embankment inside the north rock toe had been carried up to + 40 east of the spillway. The excavation through Spillway Hill for some time has been complete, and a concrete floor has also been laid below the area which is to be occupied by the dam, intended to support the regular works. As soon as the side walls and floors are finished, and provision has been completed for construction of the concrete dam, the earth dam will be carried across the west division. This will cause the river to discharge through the spillway channel. The concrete channel below the dam is 960ft. long and 285ft. wide between the walls. The floor varies in thickness from 1ft. at the lower extremity to 4ft. near the dam wall; the side walls will average 27ft. in height. The floor slopes from elevation 10 to elevation 2.2, and is laid in monoliths 30ft. by 20ft. The side walls are in 35ft. sections.

Gatun Dam is now about 60 per cent. completed, the fill upon March 1st last being 13,848,000 cubic yards, about equally divided between wet and dry, and almost two-thirds of this had been placed during the previous fourteen months. In the east half of the dam the average height of the earth toes was 77ft. above sea-level. As the height of the dam increases the dry fill of the toes is allowed to encroach upon the hydraulic fill, and by now the toes must be within a comparatively few feet of the limit prescribed for them. The dry season in Panama has now commenced, and the hydraulic fill is being allowed to dry out. It stands to-day at plus 60ft. The dry fill of the toes should be now at about 55ft. or more above sea-level, and the hydraulic fill at something over 40ft. above sea-level.

The Atlantic Division of the Panama Canal also comprises a large amount of municipal engineering, as well as an important pumping station at the Gatun waterworks; a long pipe line for Gatun, comprising a handling plant containing a total of 6700ft. of 8in. galvanised and 1168ft. of 12in. cast iron pipe; condensing water plant, entirely new water supply for Gatun, giving over 2,000,000 gallons per day; a new trunk line sewer taking 4100ft. of 10in. and 3740ft. of 12in. vitrified pipe; the laying of many thousand linear feet of macadam streets and macadam roads, cinder sidewalks and concrete retaining walls, and gutters; several thousand linear feet of other macadamised roadways; the construction of several waterworks, sewers, &c. &c., together with an immense amount of other work for which it is impossible to find room for mention in this article.

The whole of the Atlantic Division has been under the control of Major Wm. L. Sibert, Corps of Engineers, United States Army.

The Central Division.

By far the largest amount of excavation work has been done, and much yet remains to be done, in this Division, the proportion being as in the table below.

The Central Division, without either lock or dam construction, is none the less of great interest. This Division—see Fig. 3—extends from the south toe of the Gatun Dam to the north end of the lock site at Pedro Miguel, a total distance along the axis of the canal of 31.69 miles. Its engineering importance is enhanced by its containing the entire extent of the former Culebra and Chagres divisions, and which are now known as the Culebra and Chagres sections of the Central Division. From an engineering point of view this Division is full of attractiveness, for here the gradual excavation of the Culebra Cut—see Figs. 21, 22, and pictorial supplement—is ever a source of fascination on account of the gigantic nature of the task undertaken, and the astonishing celerity with which it is being carried out.

Division.	Prism.	Diversions, &c.	Locks.	Dams.	Total.
Atlantic ...	36,485,159	1,732,882	5,139,304	—	43.357,345
Central ...	95,875,018	1,250,000	—	—	97,125,018
Pacific ...	36,795,211	—	5,015,459	244,733	42,055,403
	169,155,388	2,982,882	10,154,763	244,733	182,537,766

As already stated, the Culebra Division extends from the Chagres River, near Gamboa, to near Pedro Miguel, and the original plan contemplated a channel 300ft. wide at the bottom, except for the portion of the Canal from Las Cascádas to Paraiso, where the width was fixed at 200ft. In the month of October, 1908, however, among other changes decided upon was the widening of this portion of the Canal so that the minimum bottom width throughout should be uniform, that is to say, 300ft. Fortunately, the change in plans came at a happy moment, as the material was removable much more expeditiously and economically during the dry season. The widening of the top areas, sufficient to secure the required bottom width, was finished some considerable time ago. Anyone who visits this part of the Panama Isthmus in the rainy season must be astonished at the extraordinary fall of water which has to be encountered and overcome, and the work on this part of the Canal has been retarded considerably each year by the excessive rainfall. The Obispo River and its tributaries drain the country adjacent to the Canal north of the Central Division. The streams rise rapidly after every downpour, and carry down with them large quantities of silt, gravel, and numerous large boulders. Diversion channels have been constructed to carry off such waters, and much has been effected this way; but it would be premature to state that all danger has been overcome, and that no more difficulties are likely to be encountered.

The new work on the Obispo Diversion, undertaken for the drainage on the east side, has been completed for a little over two years, and the results have proved in every way gratifying. The channel runs practically parallel to the Canal until opposite Hout Obispo, where the configuration of the ground calls for some heavy cutting through a depression in the hills, and which carries off the water in the Chagres about half-a-mile east of Gamboa. The bed of the Canal at the crossing of the Chagres River is at + 40; the low-water surface of the river is at + 43, and the excavation has long since reached grade. A part of the natural surface has been left, forming a dike which separates the river from the cut; but it is still overtopped in times of flood. Rain falling north of the summit will be carried away by gravity, but it will be necessary to do something with the water when it reaches the dike, and also with the flood waters that may reach the excavation work. To this end, four 24in. pipes have been laid through the dike, two with centres at reference 43.3, and two with centres at reference 45.9, each being fitted with suitable valves which speedily drain off the flood waters. Three pumps have been installed, and deal not only with the flood waters that remain, but also with the water that collects by draining the cut. The total height of the dike is + 70, and this has now been finished.

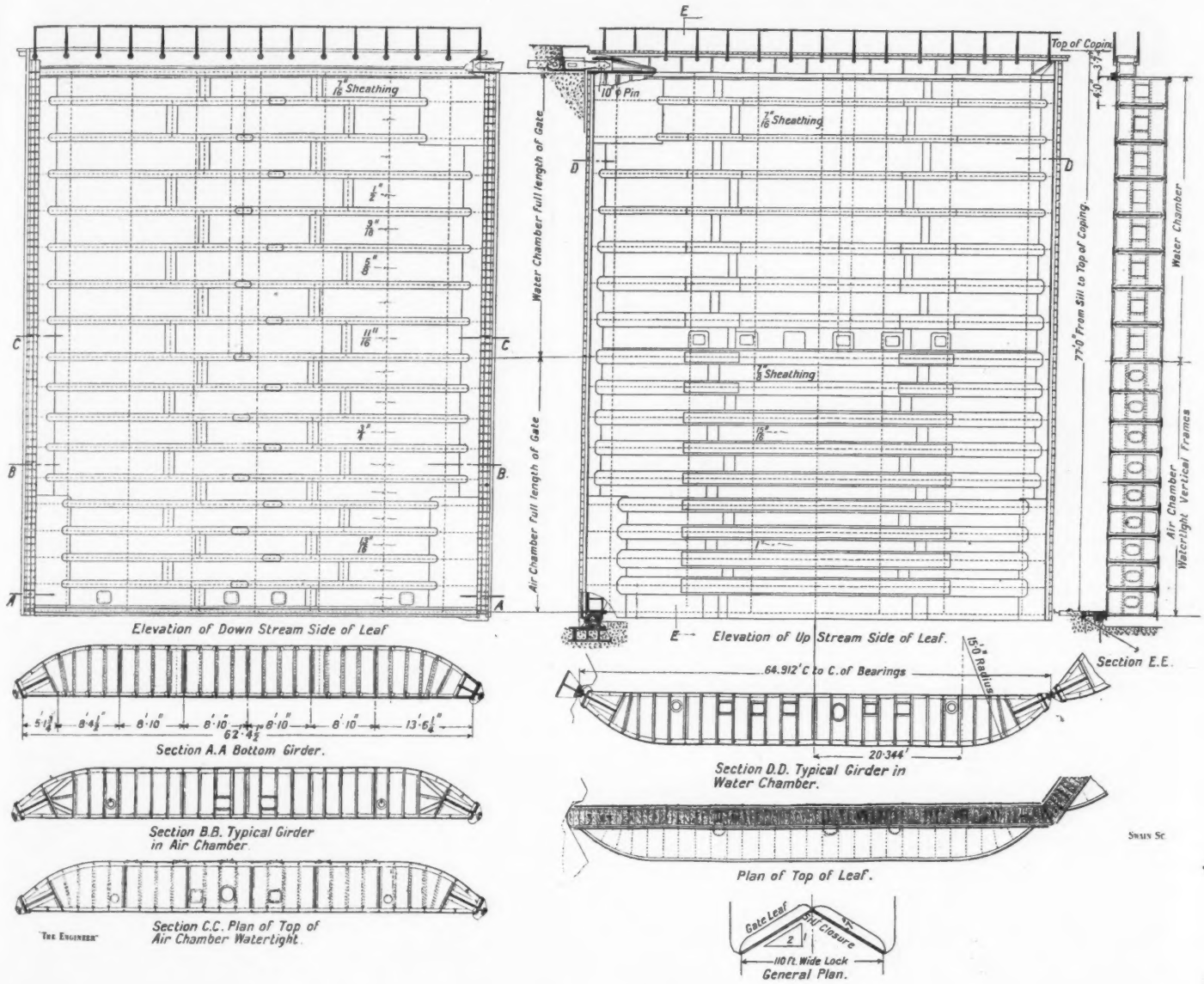

Elevation of Down Stream Side of Leaf
Section A.A Bottom Girder.
Section B.B. Typical Girder in Air Chamber
Section C.C. Plan of Top of Air Chamber Watertight.
Water Chamber Full length of Gate
Air Chamber Full length of Gate
Top of Coping
10" ø Pin
7" Sheathing
Elevation of Up Stream Side of Leaf.
64.912' C to C. of Bearings
15'0" Radius
Section E.E.
Water Chamber
Air Chamber
Watertight Vertical Frames
77'0" From Sill to Top of Coping.
20.344'
Section D.D. Typical Girder in Water Chamber.
Plan of Top of Leaf.
Gate Leaf
Sill
Quoin Closure
110 ft. Wide Lock
General Plan.

Fig. 13—LOCK GATES

Miguel, a total distance along the axis of the canal of 31.69 miles. Its engineering importance is enhanced by its containing the entire extent of the former Culebra and Chagres divisions, and which are now known as the Culebra and Chagres sections of the Central Division. From an engineering point of view this Division is full of attractiveness, for here the gradual excavation of the Culebra Cut—see Figs. 21, 22, and pictorial supplement—is ever a source of fascination on account of the gigantic nature of the task undertaken, and the astonishing celerity with which it is being carried out.

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Lake Section.

Reference has yet to be made to the Lake section of the Canal, which extends from Gamboa to Gatun, and which

was formerly known as the Chagres River Division. This part of the work has proved exceedingly troublesome, the river winding through its tortuous route crossing through the line of the Canal no fewer than 23 times, and forming a series of peninsulas which begin at Gamboa, and which have been designated as point 1, point 2, point 3, &c. Upon several occasions work has had to be entirely suspended owing to flood conditions, point 1 having proved exceptionally trying in this respect. The channel of point 2, lying between Matachin and Gorgóna, is 2700ft. long, has a bottom width of 500ft., and averages 50ft. in depth. It occupied a year and a-half to excavate this channel, over 1,784,000 cubic yards being taken out. Although the bottom of the Chagres River is slightly lower than the bottom of this cut, floods filled in large quantities of gravel which had to be removed by dredges and by trains, but all this material was made use of for concrete to revet the side slopes of the Culebra section. The engineers changed the course of the river through the completed section, thereby utilising the old bed of the river around its head as a dump. The cutting across point 3 was finished early last year (1910), having been commenced in October, 1907, some delay having been occasioned on account of the existence of the Panama Railroad upon its old embankment, and no thorough excavation could be carried out until the new embankment had been completed.

Remarkable Excavation Work.

All daily records for excavation in the Central Division were broken on Saturday, March 11th, when the total amount of material excavated within the limits of the Central Division aggregated 80,341 cubic yards. Of this amount, 79,484 cubic yards were removed by 51 steam shovels and two orange-peel cranes, the latter excavating 1191 cubic yards of material from the Canal prism. The following amounts of material were removed from the different sections of the Central Division: In the Chagres construction district, nine steam shovels of the 100-class and two orange-peel cranes excavated 13,331 cubic yards of material. In the Empire construction district, 20 shovels excavated 27,374 cubic yards of material, principally rock. In the Culebra construction district, 21 shovels excavated 37,639 cubic yards of rock and earth. In the Pedro Miguel construction district, one shovel excavated 1140 cubic yards of rock. In addition to the amounts already mentioned, there were excavated by hand work 482 cubic yards, and by scraper 375 cubic yards. Of the total amount excavated on March 11th, 79,206 cubic yards were removed from the Canal prism, 1105 cubic yards from the Obispo Division, and 30 cubic yards from outside work. Previous to the beginning of the month of March last, the highest daily record was made on April 8th, 1909, on which date the total excavation within the limits of the Central Division aggregated 78,559 cubic yards. At this time, however, Lidgerwood flat cars were credited with a capacity of 20 cubic yards, place measurement, while at the present time they are counted as containing but 19 cubic yards, place measurement, although they are being loaded as heavily as in 1909. Had figures now used for the contents of Lidgerwood cars been applied to the excavation of April 8th, 1909, the output for the day mentioned would have aggregated 76,253 cubic yards, instead of 78,559 cubic yards, as was then reported, or about 4000 cubic yards less than the total excavation of March 11th, 1911.

The whole of this construction work is under the management of Lieut.-Col. B. D. Gaillard, who is not only Division Engineer of the Central Division, but a member of the Isthmian Canal Commission as well.

The Pacific Division.

The Pacific Division—see Fig. 3—of the Panama Canal comprises the construction of the locks and dam at Pedro Miguel, the locks and dam at Miraflores, the establishment and operation of the Ancón Quarry, dredging for sand from the deposit of Chame, dredging and excavating the channel between the locks and below the Miraflores locks to deep water in the Pacific, and an immense amount of municipal and building construction, as well as much sanitary work. This Division also takes in the La Bóca dredging, as well as the Pacific locks and dams sections

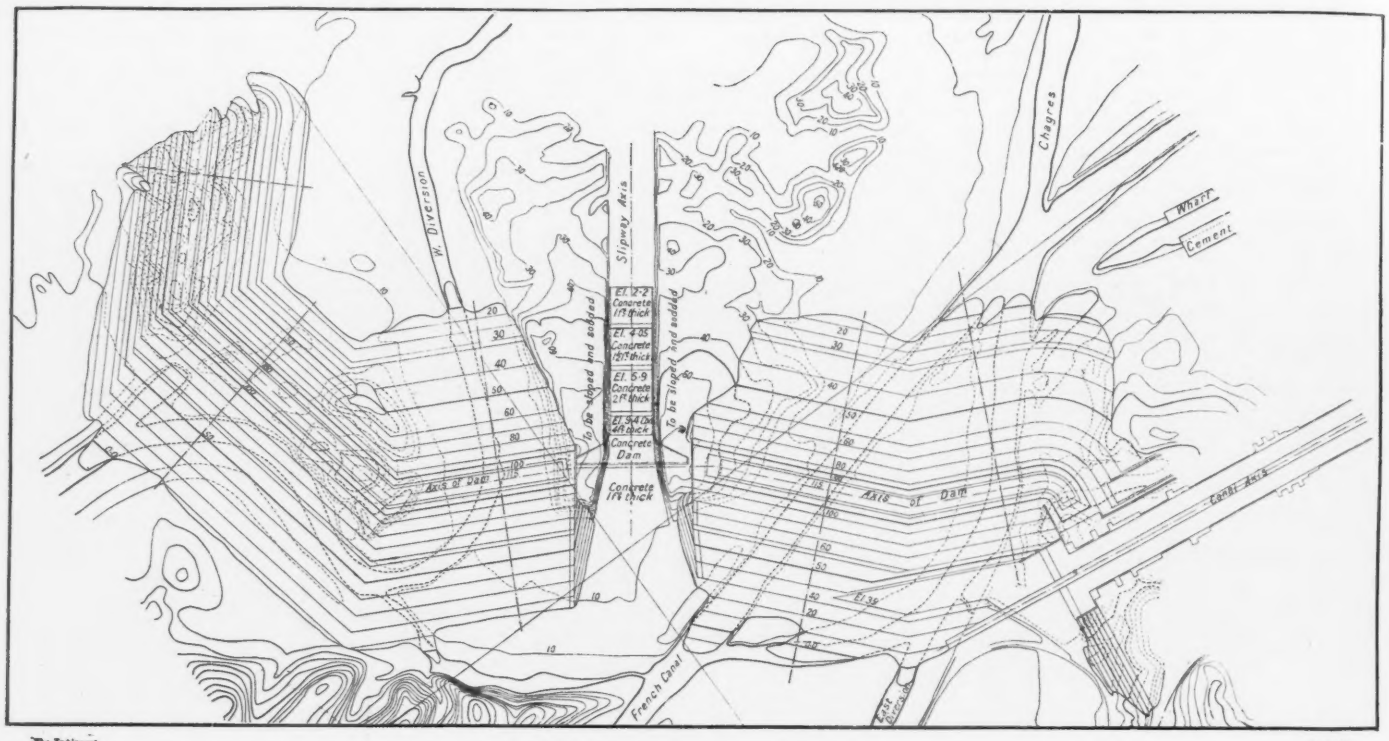


Fig. 14—PLAN OF GATUN DAM

All of the work is under the charge of Mr. S. B. Williamson, as Division Engineer.

Like other divisions of the Canal work, the Pacific Section has been divided off into districts, the first consisting of the locks and dams and dry excavation, the second of dredging and Balbóa shops, and the third the usual municipal, sanitary, and construction work. The first district is chiefly interesting from the construction work being carried on in connection with the Pedro Miguel locks and dams, the types of which are shown on the accompanying plan, Fig. 15. The East Dam is intended solely to act as a concrete core wall, situated almost entirely below the surface of the natural ground, and designed merely to prevent seepage. The West Dam will consist of impervious earth placed between rock-filled toes, and it is of unusually large dimensions, as both classes of material are being obtained from the Canal prism, and which would otherwise be wasted.

This dam will connect the lock with the hill to the north-west, and is approximately 1400ft. long, reference of top at 105, top width 50ft., and side slopes approximately 8 to 1. The maximum pressure to which it will be subjected is due to a head of 40ft. The average head is from 25ft. to 30ft. For its construction two rock piles

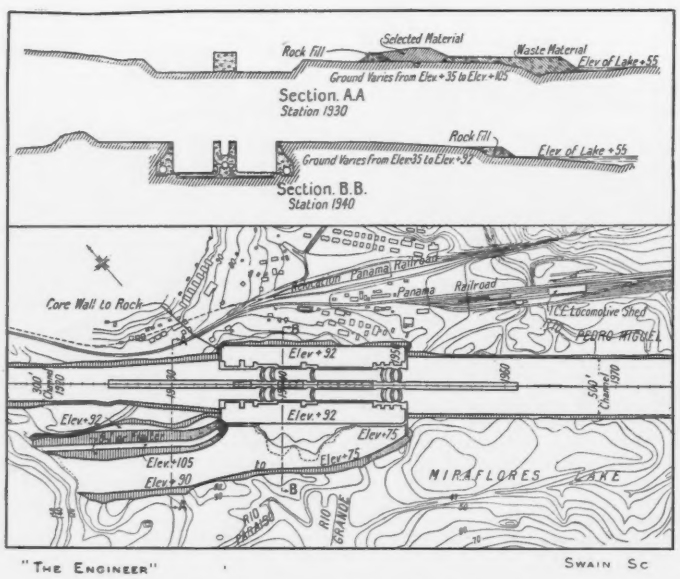


Fig. 15—PEDRO MIGUEL LOCKS AND DAM

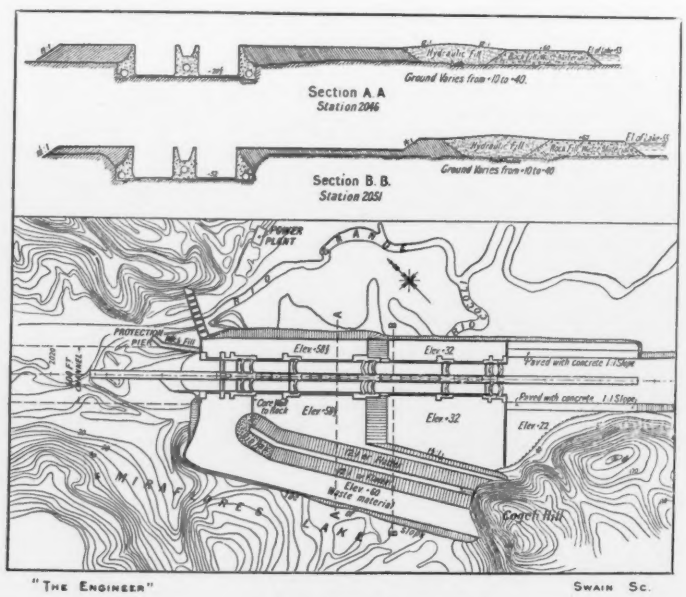


Fig. 16—MIRAFLORES LOCKS AND DAM

PANAMA CANAL WORKS—CONSTRUCTION OF GATUN LOCKS

CONCRETE WORK IN UPPER LOCK SITE, LOOKING WEST TOWARDS THE DAM—JANUARY 3rd, 1910

GENERAL VIEW OF UPPER LOCK FROM EAST WALL, LOOKING SOUTH—FEBRUARY 15th, 1910

PANAMA CANAL WORKS—CONSTRUCTION OF GATUN LOCKS

CROSS SECTION, LOOKING EAST FROM WEST WALL—JANUARY 15th, 1910

UPPER LOCK, LOOKING SOUTH FROM EAST WALL—MARCH 1st, 1910

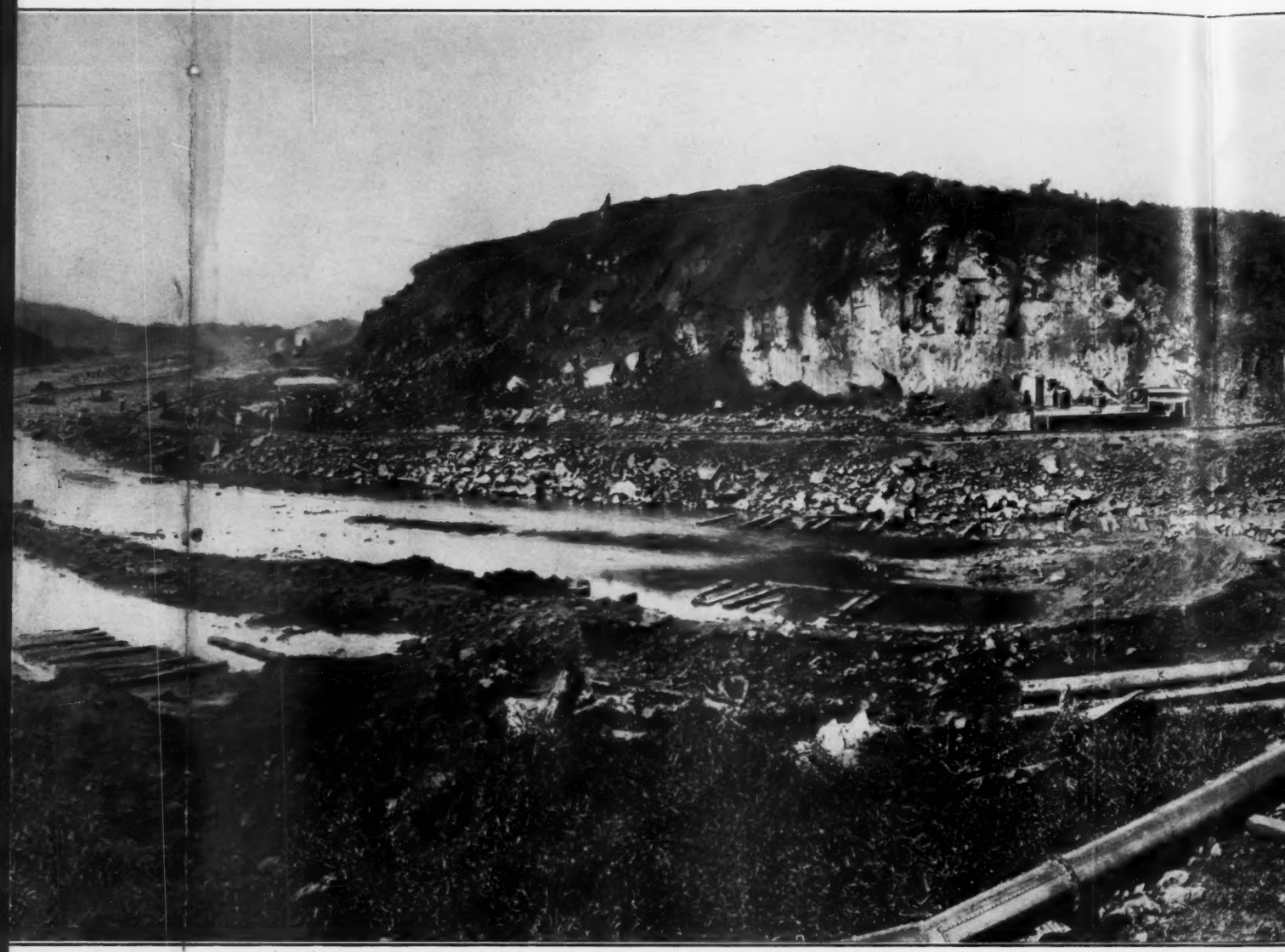
THE PANAMA C

SITE OF THE SPILLWAY THROUGH GATUN DAM, SHOWING THE EXC

VIEW IN THE CULEBRA CUT, LOOKING SOUTH—FEBRUARY, 1907

VIEW FROM THE SAME POSITION TW

ANAMA CANAL WORKS



UN DAM, SHOWING THE EXCAVATION PRACTICALLY COMPLETED—DECEMBER 1st, 1908

ROM THE SAME POSITION TWELVE MONTHS LATER

CONSTRUCTING THE DAM FOR GATUN RESERVO

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EXCAVATION WORKS O

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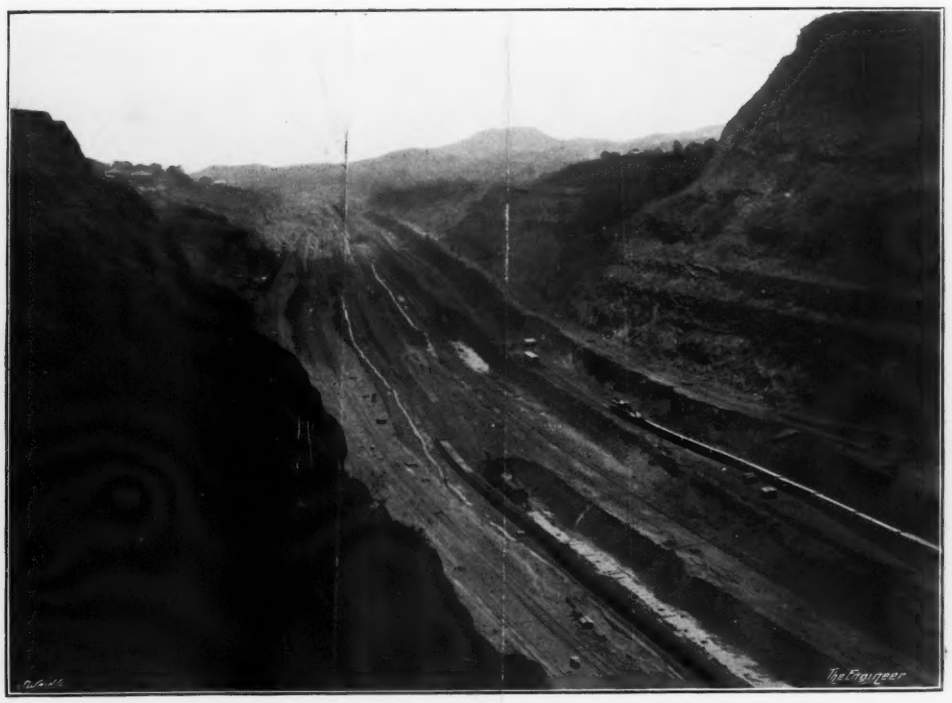
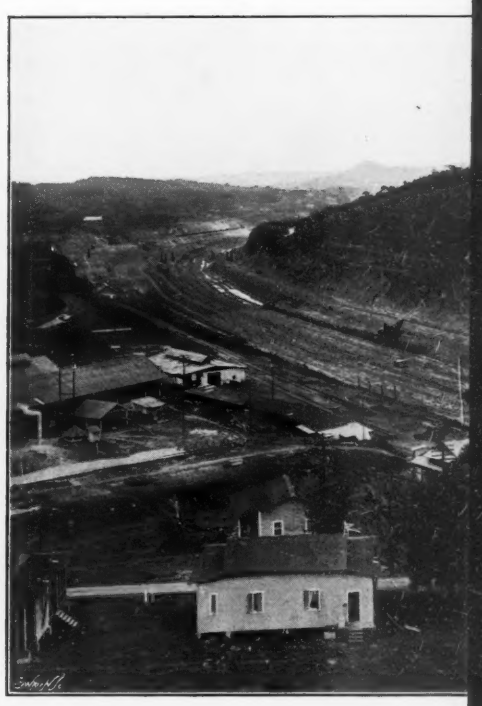
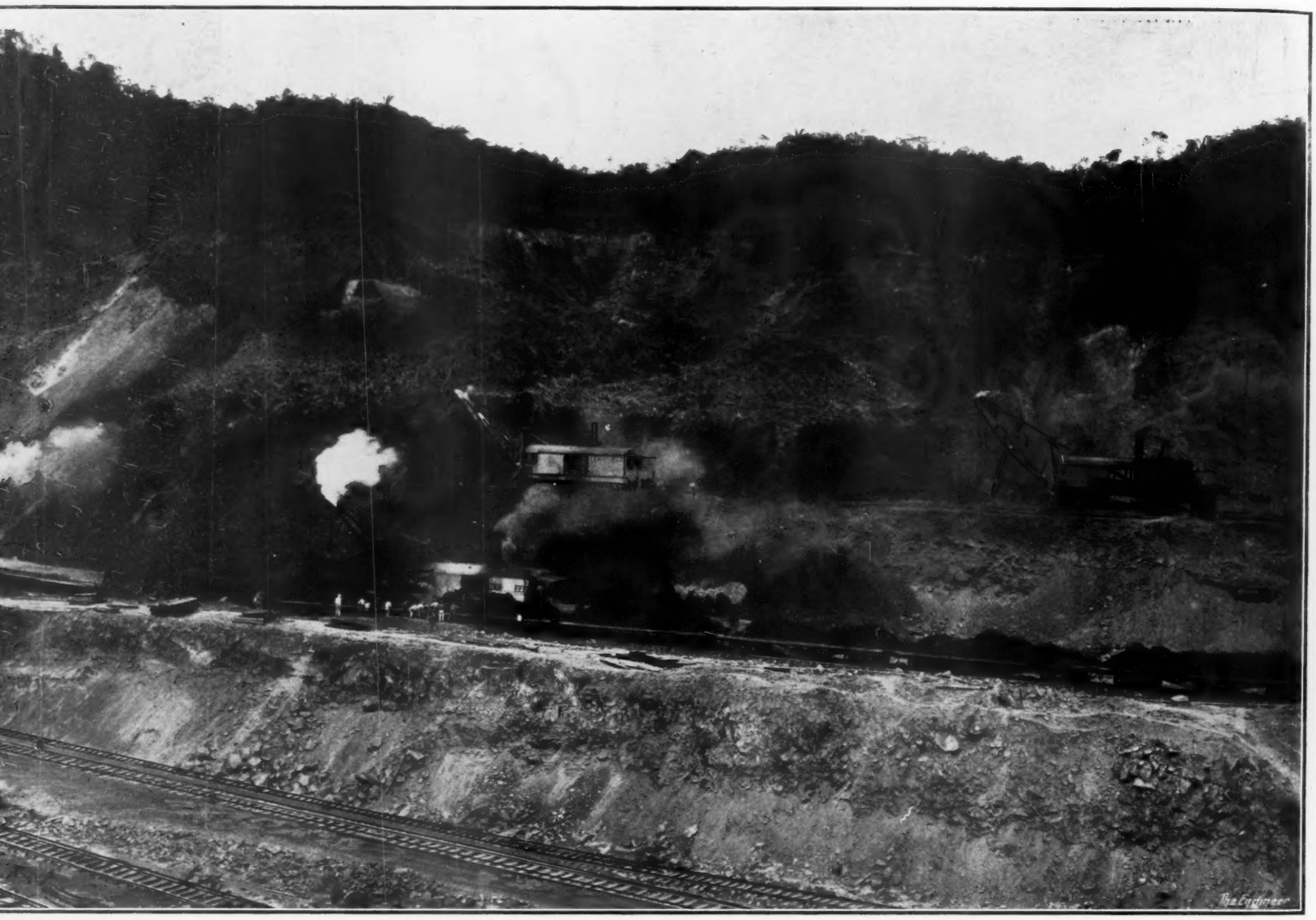


CULEBRA CUT, LOOKING NORTH FROM CONTRACTOR'S HILL—APRIL, 1910



THE CUT, LOOKING NORTH FR

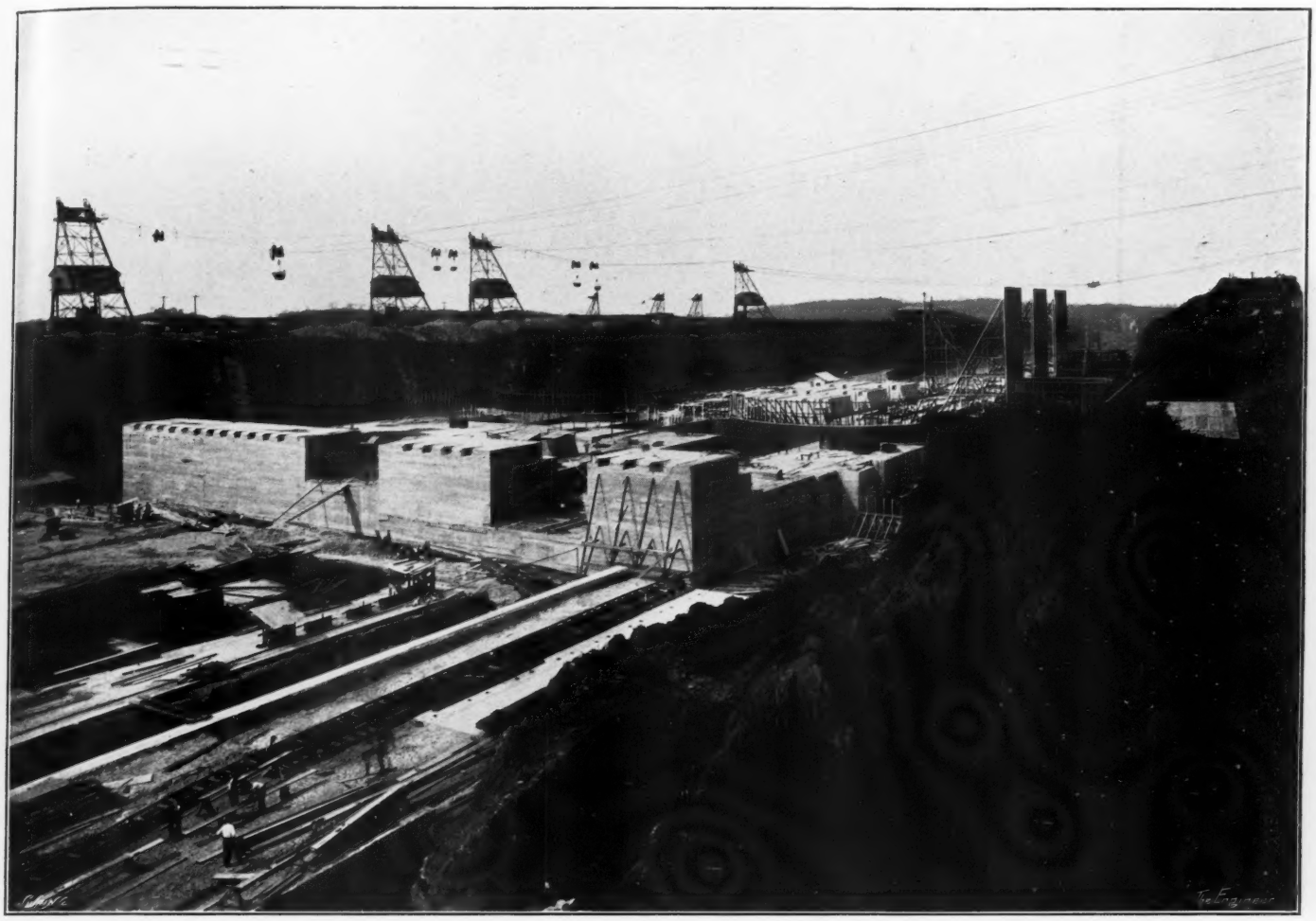


SLIDE—APRIL 20th, 1909

FROM EMPIRE HILL, JANUARY, 1910

THE CUT AT EMPIRE, LOOKING NORTH

PANAMA CANAL WORKS—CONSTRUCTION OF GATUN LOCKS

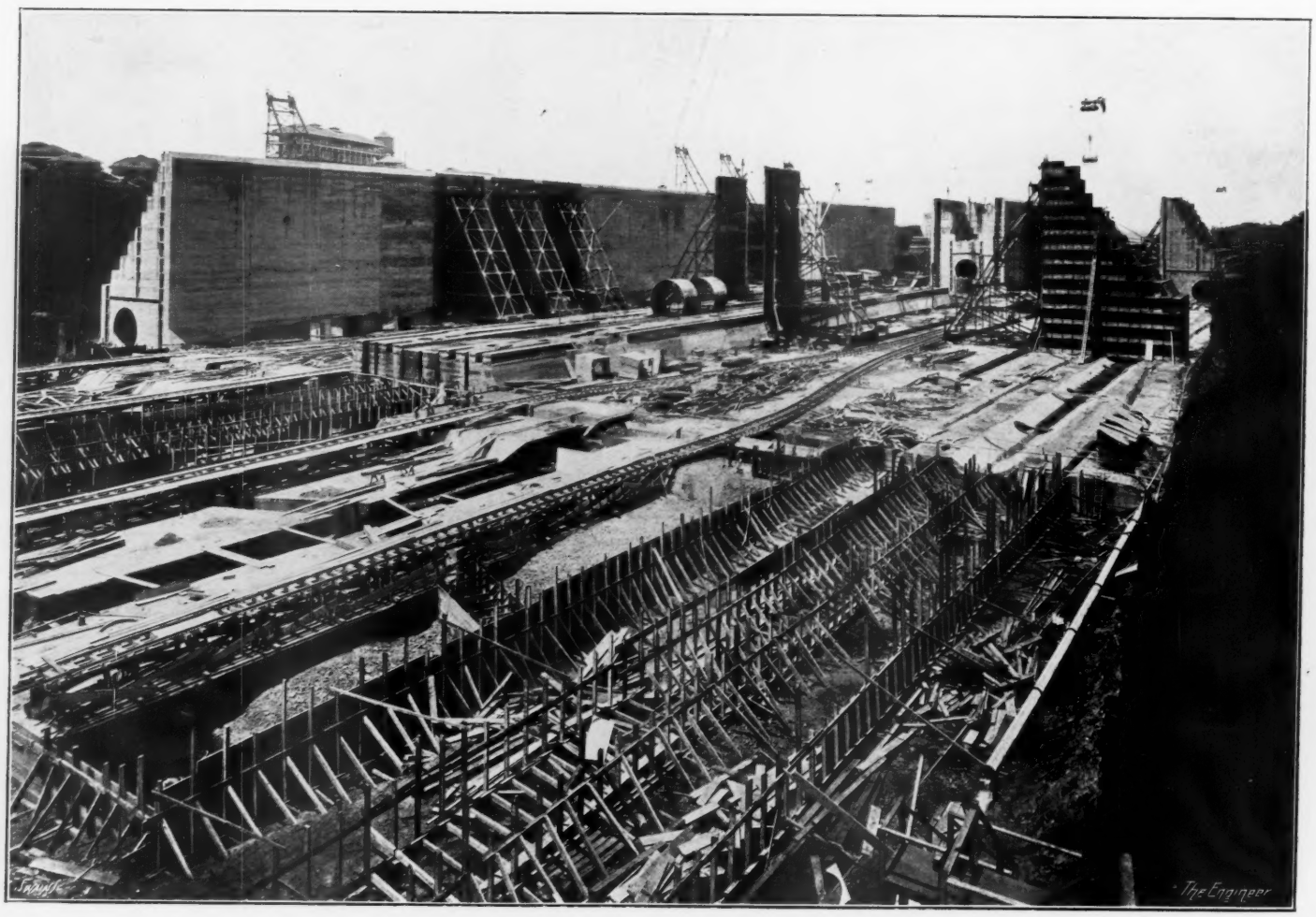


LOOKING NORTH FROM EAST WALL—JANUARY 15th, 1910

CONCRETE WORK, UPPER LOCKS, LOOKING SOUTH—FEBRUARY 1st, 1910

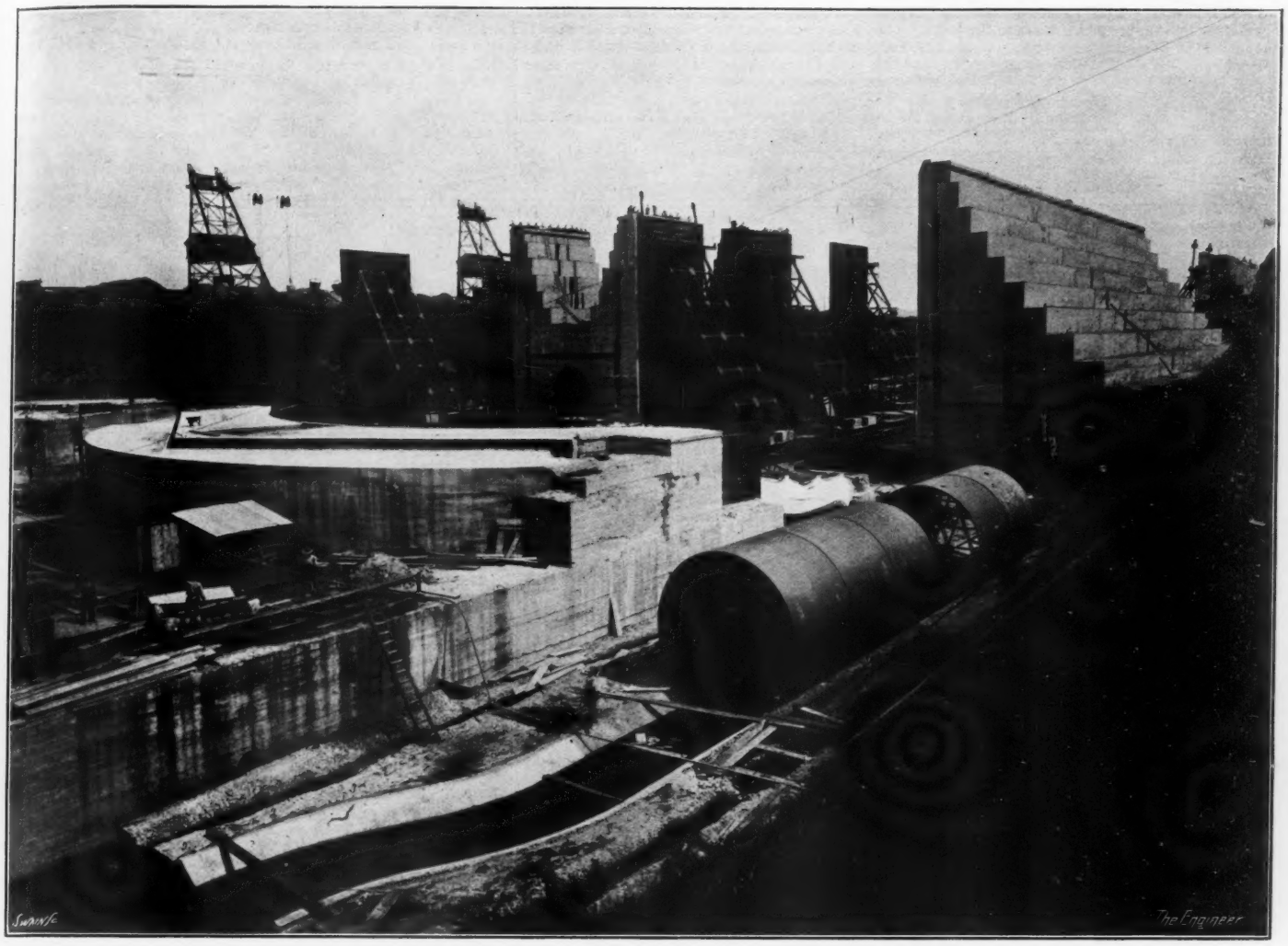
PANAMA CANAL WORKS—CONSTRUCTION OF GATUN LOCKS

LOOKING NORTH FROM WEST WALL—MARCH 15th, 1910

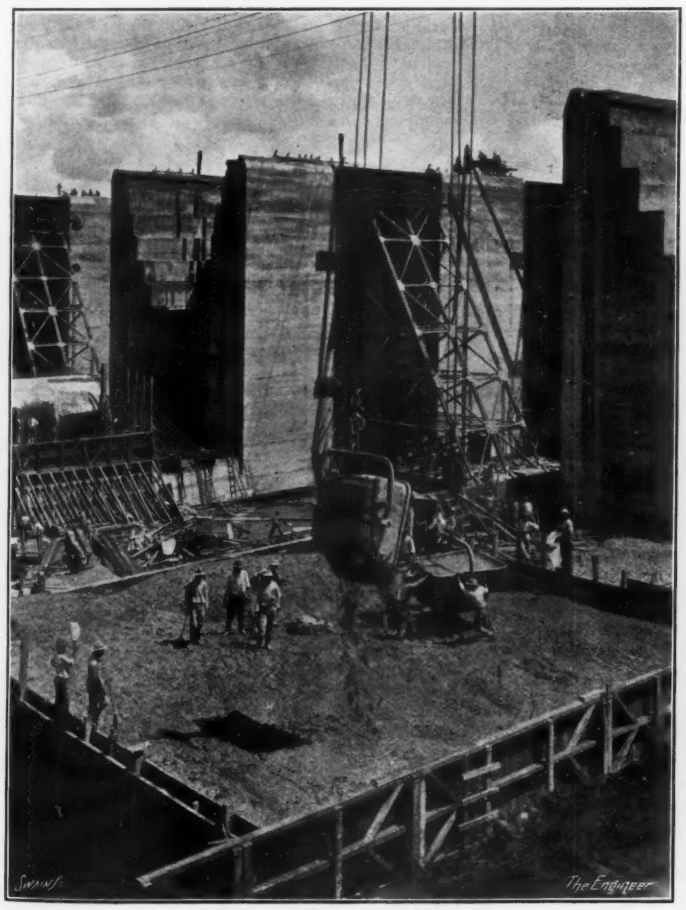


UPPER LOCKS, LOOKING SOUTH FROM WEST BANK—JUNE 2nd, 1910

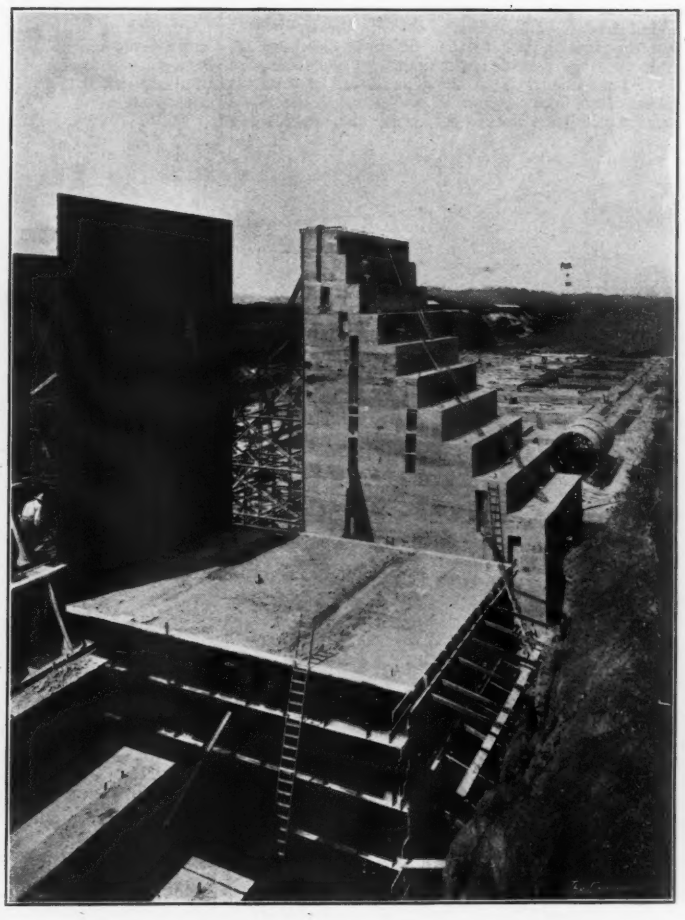
CONSTRUCTION OF THE UPPER LOCK AT GATUN



GUARD GATE MITRE SILL IN FOREGROUND—APRIL 15th, 1910



CONSTRUCTING MONOLITHS—JUNE 2nd, 1910



FIRST SIDE WALL MONOLITH COMPLETED—FEBRUARY 1st, 1910

have been formed, consisting of spoil from the lock excavation; between is puddled clay placed mechanically and well settled by water jet. The minimum thickness at the bottom of this clay core is 130ft. The dam will be tied to the hill against which it abuts, and to the west wall of the lock, by concrete core walls. The only feature which has not yet been decided upon is the precise character of the approaching piers to the locks. The natural surface of the ground between the east lock wall and the adjacent hill is at sufficient elevation, but the upper portion is more or less pervious. To cut off any possible flow the lock wall is being turned towards the hill with which it is being connected by a concrete core wall resting on rock 550ft. long, 4ft. thick at the top, and 10ft. thick at the bottom. The natural foundation of the dam is impervious, except for a distance of about 300ft. across the original bed of the Rio Grande, where there exists a layer of pervious gravel of about 4ft. in depth immediately over the rock. A trench measuring 20ft. in width has been excavated at this spot through the gravel and bed-rock, and then refilled with puddled clay, making the whole foundation impervious.

Great progress was made during the past year, 1909–1910, in the work of excavation. The laying of concrete in the lateral culvert floors and the whole foundation have also well advanced. A dyke has been constructed across the south end of the lock site to prevent tide waters from entering the chambers, while a pumping plant has also been installed to deal with all surface and seepage water.

The Miraflores locks and dams, the design for which are illustrated on the accompanying plan, Fig. 16, extend from the upper gate abutment to Cocoli Hill, and the West Dam performs a double function of maintaining the lake and protecting the lock site from the Rio Cocoli. This dam will consist of a hydraulic fill between the rock-filled toes, and all of the necessary material is being taken from the Canal prism. Concrete core walls are being constructed for connecting the dam with the lock wall, and with Cocoli Hill at the north and south ends respectively. Except in the bed of the Rio Cocoli, the foundation is compact and impervious; but where it is not so, a trench 20ft. in width has been excavated along the axis and bed-rock, and carefully puddled, a ditch of the same width and averaging 12ft. in depth having been carried throughout the main length of the foundations to assist in holding the filling and a natural soil together.

The East Dam will be of concrete on a rock foundation, and will be provided with a spillway for regulating the lake level. The length of the dam will be approximately 500ft., and it will be provided with regular works similar to and of the same dimensions as those in the spillway at Gatún, the crest in this instance being at elevation 39, and the openings provided will permit of a discharge of 75,000ft. per second. While the general plan of the East Dam has been finally approved and adopted, the exact details are still being worked out, while the approaching piers of the locks also are still under construction. The locks themselves will be of concrete, and with the usual systematic organisation which is so characteristic of the entire undertaking, a special quarry has been opened for these locks on the face of the adjacent hill.

Part of the lower lock excavation in Miraflores was accomplished by the hydraulic process, and the work has now been extended to the section of the Canal prism lying between the lower lock and the dredged channel to Balbóa. The process involves the disintegrating and sluicing of the original material by means of powerful pumps forcing the water at a high pressure through four monitors, and the lifting of the material thus disintegrated out of the pit by dredge pumps. Most of the material disposed of so far has been utilised in making the core fill of the West Dam at Miraflores, but as this work draws to a conclusion it will be used for reclaiming the tidal swamps between Corozál and the Canal. The total excavation during the month amounted to 64,434 cubic yards.

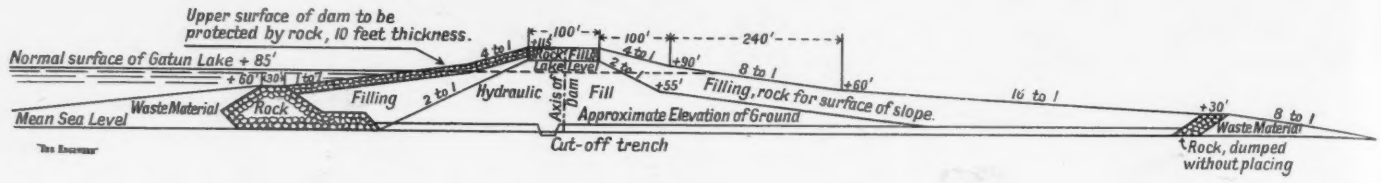


Fig. 17—SECTION OF GATUN DAM

Filling and Embankment.

Up to 31st January last no additional dry filling had been added to the prism of the West Dam at Pedro Miguel, the total amount of material in place at the end of that month remaining at 260,852 cubic yards. The back-fill at Pedro Miguel had increased 31,072 cubic yards, the total in place at the end of the month amounting to 61,159 cubic yards. At Miraflores 24,685 cubic yards were added to the dry fill in the toes, and 89,243 cubic yards to the hydraulic fill in the core of the West Dam, making the totals at the end of the month 634,548 cubic yards and 383,955 cubic yards respectively. The back fill was increased by 1060 cubic yards, making the total amount in place at the end of the month 134,605 cubic yards.

The excavation for the centre wall in the fore-bay has been completed, and the concrete work already commenced. The laying of the tracks for the purpose of back-filling the west wall has now been finished, and the work begun. The concrete work at Pedro Miguel for January last showed a decrease of 3871 cubic yards over the figures for the previous December. The total amount placed was 38,513 cubic yards, including 113 cubic yards of large stone. The concrete was placed as follows:—18,536 cubic yards in the centre wall; 8507 cubic yards in the west wall; 1298 cubic yards in the west head wall; 9706 cubic yards in the east wall; and 466 cubic yards in the floor.

Miraflores Locks.

Work on the west storage trestle at Miraflores was continued during the same month—see Figs. 27 and 28—and the filling of the dike at the Agua Dulce pumping station was commenced.

The hydraulic excavation plant was removed from the lower lock site, with the exception of two monitors and a relay pump, which are engaged in cutting out the barrier between the upper and lower lock sites. A steam shovel was employed in excavating an incline into the lower lock site, in order that the rock excavation by steam shovels can be completed.

The total amount of concrete and large stone laid was 24,018 cubic yards, as compared with 21,533 cubic yards during December. The concrete was placed as follows:—7482 cubic yards in the centre wall, 14,611 cubic yards in the east wall, and 1925 cubic yards in the floor.

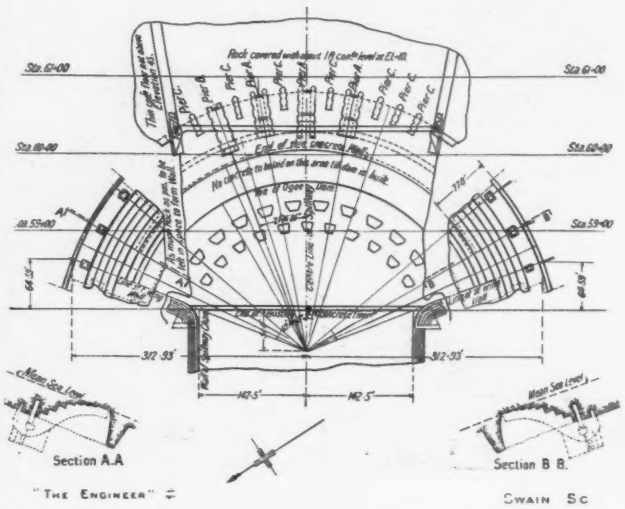


Fig. 18—GATUN SPILLWAY

Pacific End Canal Entrance.

It will be desirable to give here some particulars of the important engineering undertaking now proceeding at the Pacific end of the Canal, where a commodious harbour, or anchorage basin, is about to be constructed. I have been privileged to see the plans which have been approved by the Canal Commission, and active work has been commenced. In accordance with the plans already referred to, the eastern edge of this harbour will extend from the new sand dock along the old railroad embankment, built while work on the abandoned Sosa-Corozal dam project was in progress, to the site of the dam, and thence north for a distance of about 750ft. Its limits will then be extended in a straight line in a westerly direction, crossing the present bed of the Rio Grande, until the Canal is reached, the western edge of the latter channel constituting the western boundary of the basin. The total area will be approximately 176 acres, and the greater part of it, outside of the Canal channel, will have to be dredged, the estimated amount of material required to be removed aggregating 1,000,000 cubic yards. At the time that I was upon the Isthmus a long spit of land, showing above water, was pointed out to me as extending down to about opposite the shipways at Balbóa, separating the channel from the river entrance, and this will involve the heaviest part of the dredging within the basin. The harbour will have a uniform depth of about 40ft. at mean low tide.

It is not intended that the work of preparation shall in any way interfere with the regular Canal operations, nor was the dredging work to be commenced until the Canal channel was well on toward completion and there is less work to be done. When the basin is finished, plans will be considered for a permanent system of piers or docks

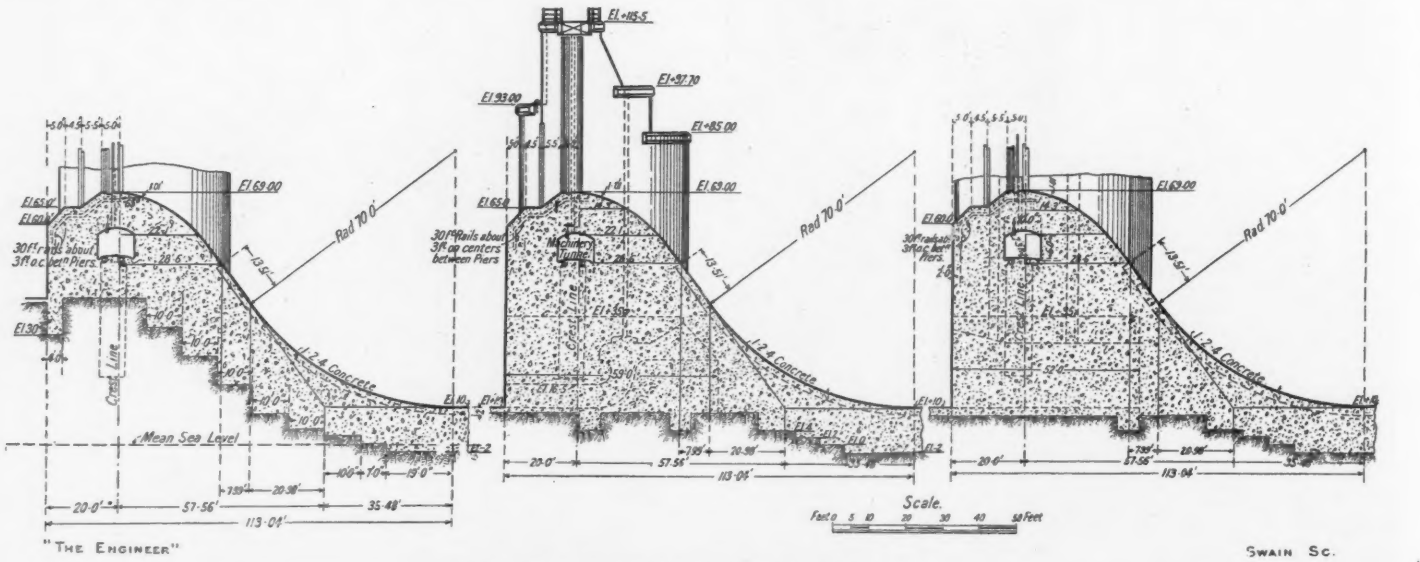


Fig. 19—GATUN SPILLWAY—SECTIONS OF SPILLWAY DAM

extending from the sand dock along the east side of the harbour, and should the shipping business by that time give sufficient encouragement, it will be carried along the north end of the harbour as well. The Rio Grande channel will be eliminated by the formation of Lake Miraflores, and much of the ground in the immediate vicinity of the harbour, now low and partly covered by water at high tide, will be reclaimed. I understand that the piers are to be constructed so as to extend directly out from shore, at a distance of 500ft. apart, which will enable ships of any tonnage to berth alongside, two to each dock. Under these circumstances the present Panama Railroad docks will have to be removed to the new site. It is said that the new harbour will afford an absolutely safe anchorage, as it will be completely land-locked, with no sea disturbances, barring the rise and fall of the tides, and merchant shipping will be held secure from all attack, the harbour being directly under the lee of the proposed fortifications on Sosa Hill.

The Canal at the Pacific entrance is completed from deep water to a point opposite the Panama railroad wharf at Balbóa, a distance of about five miles, and apart from the removal by the suction dredge Culebra of a few loads of fill each month, there is no further dredging to be done in that section. The open-water channel continues inland for a distance of about three miles from the Balbóa wharf, and in this part of the Canal three of the dredges are now working. The depth of the channel varies from 30ft. to 45ft. at mean tide, and certain sections of it have been excavated to its final width of 500ft. Considerable work, however, remains to be done on the west bank, where several rock patches project into the channel, and these are being drilled and mined preparatory to their removal by the dredges. Two of the Pacific Division dredges were recently set at work in the prism south of the dam at Miraflores, as their ladders are not long enough to permit them to continue the excavation in the open channel, except at mean tide, or below, and to keep them there would necessitate laying off one crew and working only a twelve-hour day.

Atlantic Side Canal Entrance.

With regard to the Atlantic side entrance to the Canal, work has been going on for some time, and there four distinct classes of excavation have been in progress. The entrance will extend from deep water in Limon Bay to Gatun Locks, about seven miles. The work comprises dredging under water, cutting a channel into the land by means of dredges, steam-shovel excavation, and excavation by suction dredges. The channel is to be 500ft. wide and 41ft. deep at mean tide. From deep water in the bay to the shore line the material is largely composed of earth and loose rock, all of which is handled easily by means of ladder dredges, a dipper dredge, and a sea-going suction dredge. Some hard rock below a depth of 30ft. is being drilled and blasted. When I saw it last the channel had been dug to a considerable depth, but the silt carried into the channel by the various currents was giving trouble, and it seems that there will be required a large amount of maintenance work which will be done chiefly by the suction dredge. To lessen the amount of this maintenance work, and to provide protection for the shipping in the harbour against violent "northers" which prevail here once or twice a year, in all likelihood breakwaters—Fig. 23—will be built across the front of the bay, leaving an opening 2000ft. wide for ships to enter. The plans also contemplate a west jetty with the outer end in 48ft. of water, and trending toward Toro Point, and an east jetty from 44ft. of water, trending toward Manzanillo Point.

In this Atlantic entrance to the Canal the channel is completed to its full width of 500ft. as far as the French canal, which is 5 miles and 2438ft. inland from deep water in Limon Bay. The channel is 40ft. deep to a point 3900ft. from deep water, 35ft. to a point three miles inland, 30ft. deep to a point four miles and 800ft. inland, and 20ft. deep as far as the French canal. The amount of material to be excavated in this section is 30,600,000 cubic yards of earth, including fill, and 3,800,000 cubic yards of rock. On March 1st, 20,175,000 cubic yards of earth had been taken out and 2,250,000 cubic yards of rock, the earth excavation being 66 per cent. and the rock 59 per cent. completed. The plant engaged in this work includes a sea-going suction dredge, three old French ladder dredges, and two modern dipper dredges, and auxiliary fleet. The excavation of rock under water is accomplished by drilling and blasting the rock prior to dredging. The drilling is done by eight common well drills mounted on a barge served by one boiler, and moved from place to place, according as the work is completed. This excavation is being done at less cost than dry excavation, the greatest element of economy being the method of drilling, in which the whole battery of drills is moved at one time, and is served by a small force of men.

From the shore-line to the hills at Mindi, a distance of one mile, the channel is through a salt marsh, in which a layer of earth overlies hard rock. This material is blasted in the dry with dynamite, and it is then taken out by the dipper and ladder dredges, which work their way into the land, making a channel 500ft. wide and 41ft. deep. At Mindi four steam shovels have been working below sea level in a pit which was kept dry by pumping. One of these shovels has been excavating at 41ft. below mean tide, or, in other words, on the bottom of the Canal. Up to last year no work had been done on the section between Mindi and Gatun locks. This consists of a channel 500ft. wide up to a point 4000ft. north of Gatun Locks, and 1000ft. wide from that point to the locks. Suction dredges are used on this part of the work, and about 4,500,000 cubic yards of stuff will have to be excavated.

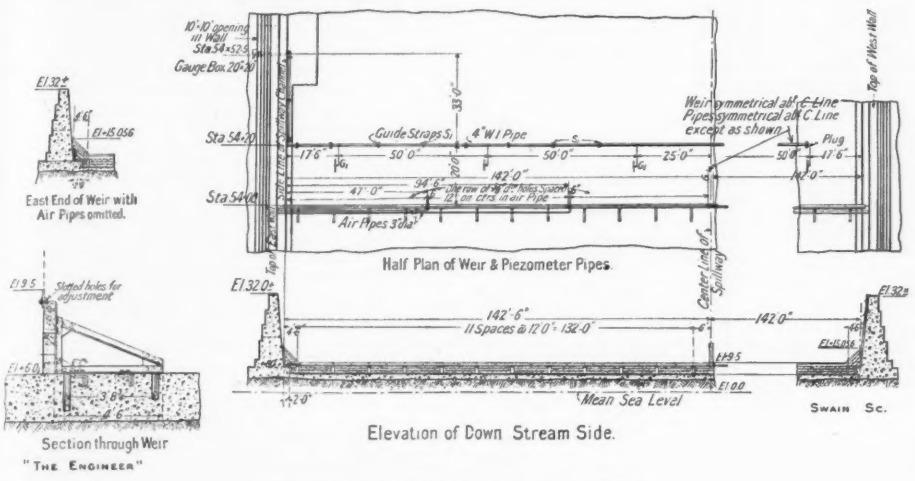

East End of Weir with Air Pipes omitted.
Section through Weir
"THE ENGINEER"
Half Plan of Weir & Piezometer Pipes.
Elevation of Down Stream Side.
Mean Sea Level
SWAIN SC.

Fig. 20—GATUN SPILLWAY, WEIR IN CHANNEL

While I am on the subject of excavation I should like to set forth definitely the much debated matter of the amount of excavation which was done by the French at the time that the Americans took over the Canal work, and how much has been done by the latter up to the present. The French estimated that they had excavated about two-fifths of the total amount necessary for the Canal which they proposed to construct. This amount was very considerably less than will have to be done; but at the same time that the Compagnie Universelle du Canal Interocéanique came to an end, which, if I remember rightly, was in the month of December, 1888, the amount of excavation done was some 72,000,000 cubic yards. When the United States took possession in May, 1904, the type of the Canal which it proposed to construct had not been decided, nor was it so decided until two years later, namely, in 1906. On June 29th of that year the President of the United States approved an act of Congress directing the construction of an 85ft. level lock-canal. The total excavation estimated for that canal by its authors at the time was 103,795,671 cubic yards, in addition to the French excavation. This plan was subsequently changed in many important respects, also by order of the President, the net result being to increase the total excavation required to 174,666,595 cubic yards, making it nearly 71,000,000 cubic yards larger than the original estimate. If the plan of the Canal originally adopted had been adhered to, the total excavation would, by now, have been within 8,000,000 cubic yards of completion. As it is, something more than two-thirds have been completed. I understand that the average daily output of excavation, even during the wet weather, which may be taken from May to October is over 100,000 cubic yards.

What "rain" means in Panama may be understood when it is said that in the space of an hour (one August), 5in. of rain fell at Cristóbal, the fall commencing at 3.40 o'clock and lasting until 5.15, in which time—1 hour and 35 minutes—6.03in. of rain fell. The heaviest record, however, was that of June 2nd, 1906, when 5.86in. fell in one hour, from 4 to 5 o'clock in the afternoon, at Balbóa. Considerable difficulty is still felt in getting rid of the immense amount of rain falling even when all precautions are taken.

Colon Breakwaters.

Reference has been made above to Toro Point, which is an extremity of a peninsula extending into the Caribbean Sea, and forming the westerly shore of Limon Bay. It is here that work has recently been commenced upon the Colón breakwaters, which have been under consideration since December, 1906, when plans were first submitted. The idea then was to construct two such breakwaters, one extending from the beach to the east of Colón lighthouse in a north-west direction one mile, the other starting from a point 3750ft. west of Manzanill Light, running one mile to a point where the depth at mean low water is at least 40ft., so placed as to afford an entrance between the extremities of these breakwaters 1000ft. in width, the southerly extremity of the latter breakwater to be connected with Great Reef, off Mindi Point, by a breakwater, or stone dike, 2½ miles in length, the general direction being parallel to the Canal. This scheme, however, was not approved, and a second project was introduced to place the west breakwater in a north-easterly direction from Toro Point, and to place the east breakwater in a corresponding position. This change in the plans puts the entire bay under the protection of the breakwaters. The opening has been advanced to 44ft. of water, while the breakwaters have advanced, parallel to themselves, to 48ft. of water.

When the Canal is completed, the peninsula at Toro Point will become virtually an island separated from the mainland by the Canal as far as Gatun on one side, and by the Chagres River, which will receive the surplus water of Lake Gatun, after passing over the spillway of Gatun Dam, on the other. Toro Point Light is 2⅞ miles from Colón Light, and about four miles from Dock 13. The point extends into the sea in an easterly direction, and is surrounded by dangerous reefs and shoals, vessels approaching Colón harbour from the west being compelled to make a wide detour to avoid them. Immediately south of the Toro Point lighthouse is a small harbour known as Shelter Cove, which will be utilised by the engineering forces as a landing place for material and supplies. The entrance to this harbour is narrow, while reefs and shoals encroach upon it from both sides; but it is intended to enlarge the channel, and both this and the harbour will be dredged to a depth of 16ft., which will admit the towing tugs, with one or two exceptions.

It was only in June, 1909, that the funds for constructing this part of the Canal's breakwaters became available, but rather than lose any time in commencing operations the chief engineer authorised the construction of the necessary buildings, such as engineers' residences, labourers' barracks, commissary, hotel for the employés, workshops, &c., there being a surplus in the fund allotted for new construction in another department which was available. The first part of the breakwater construction being taken in hand is the west breakwater, from Toro Point at an angle of 42 deg. and 53 minutes from Colón Light.

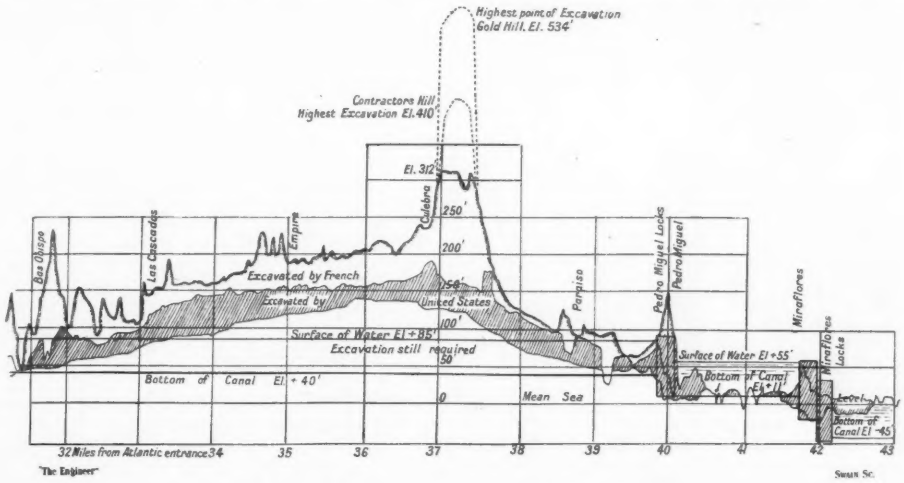


Fig. 21—CULEBRA CUT AND PACIFIC SLOPE LOCKS

West and East Breakwaters.

The west breakwater will be about 10,500ft. in length, with a width at the top of 15ft. and a height above mean level of 10ft. The width at the bottom will largely depend upon the depth of water. The survey of the bottom of the bay along the line of the breakwater showed the greatest depth to be about 43ft., and at this point the embankment will approximate to 180ft. in width. The east breakwater will be an isolated structure, situated at an interior angle of about 135 degrees to the west breakwater, and will be 5700ft. in length, with the other dimensions practically the same as those of the west breakwater—see Fig. 23.

The amount of fill required in the construction of the two breakwaters is 4,915,000 cubic yards, about one-half

of which will be material excavated on the Point for the core of the west breakwater, and the balance Porto Bello rock. The east breakwater will require about one-half as much material as the west breakwater, but the cost of construction will be relatively larger, because the fill will probably have to be made entirely by barges and scows. The construction of the inner end of the west breakwater will proceed by driving piling for trestles, on which a track will be laid and trainloads of material hauled out on it and dumped. The shore end will be built entirely of Toro Point rock, in order to observe the effect of wave action. The width of the ship channel between the ends of the two breakwaters will be 2000ft., measured at right angles to the centre line of the canal prism. The total cost of both breakwaters will be 11,543,600 dols.

A New Town.

By the time these lines appear in print, in all probability upon the site of the breakwaters above described will have sprung up one of those remarkable settlements for which the Americans are famous. The surface of the ground is only 2ft. or 3ft. above mean sea level, while the beach soil, for the most part, is coral sand mixed with vegetable mould overlying coral; but in a few weeks time, after commencing operations, this place will be blossoming like a garden, and the houses of the servants of the Canal Commission will be springing up, like Jonah's gourd, in a single night, but, unlike that eccentric vegetable, destined to last at least a longer time. This site is very much like that of Cristóbal, which, again, is one of the extraordinary evidences of the enterprise and ingenuity of the Americans in town building. So complete is Cristóbal in this respect that I think a description of it may be of some interest to readers of THE ENGINEER, more especially as it is but a proof of the manner in which the Panama Canal builders attend to detail.

Cristóbal is to-day the most important town on the Canal zone, and its future is destined to be even more important still, since it will be one of the permanent and most attractive cities on the Isthmus. Originally the place was a part of Colón, and became separated

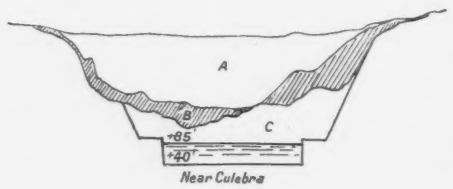


Fig. 22—CROSS SECTIONS OF THE CULEBRA CUT

from it as a distinct municipality when the zone boundary line cut it off from the rest of that town. Cristóbal and Colón were both so called after the great Spaniard, Christopher Columbus (Spanish, Cristóbal Colón), whose name at one time was given to the whole of the Panamanian Isthmus.

Cristóbal has two large docks which are the property of the Panama Railroad, while a third is now being constructed. There is also a well-equipped dry dock. Dock No. 13 runs along the old French Canal, and is situated between Dock 14 at the dry-dock shop, and Pier 11 near Cristóbal Point. The whole town is devoted to the uses of the Canal, and as a place of residence for the workers; while there are a number of huge factories and plants which serve to give it the appearance from a distance of a huge manufacturing town. The wharf is 1200ft. in length, and construction was found extremely difficult throughout, very long piles, requiring the splicing of about 800 piles, being used. No fewer than 85ft. piles were used for all fenders. All ships of the Panama railroad discharge at this wharf, while the extensive railway shops are also situated at Cristóbal. There are hundreds of well-built houses, all numbered and screened from mosquitoes by wire netting, long streets macadamised from end to end, attractive gardens laid out, and a first-rate water supply, every house being attached to the main. The principal street follows the seashore from Colón to Cristóbal Point, and this is lined upon both sides with rows of palms. The shore is outlined by a great number of massive concrete blocks, each weighing between 40 and 50 tons, which were brought there from France during the time of the French occupation. All this is "made-land," and without some such protection the sea, which is continually encroaching, would speedily wipe the town out of existence. The Americans maintain excellent order in the town, and while the methods of the police may be somewhat drastic from our point of view, the revolver being far too readily employed, considering the character of the majority of the labouring men who are engaged here, strong measures are naturally necessary, and the employment of the *fortiter in re* more desirable than the *suaviter in modo*. American power is supreme here, and the Panamanians have nothing whatever to say with regard to the control of the town or its inhabitants.

Cement Loading Plant.

While dealing with Cristóbal, I desire to say something concerning the excellent arrangements made there for the unloading of the immense quantities of cement which are being used, by means of cement conveyors. There are altogether 6 conveyor units, 2 for cement in bags, and 4 for cement in barrels. Each unit has a maximum capacity of 1000 bags or barrels per hour. At the time that I saw these arrangements they were working without a hitch, and some idea of the amount of stuff which will have to be carried can be gauged from the fact that the Canal construction calls for another 4,000,000 barrels of cement. I may mention that each of the steamships engaged in carrying the cement makes one round trip a month, between New York and Cristóbal, and each has a maximum capacity of approximately 10,000 tons of cargo, usually about equally divided between cement and general freight. The steamers have the same arrangement of hatches, all of which have a clear opening of 17ft. 4in. by 20ft., except one hatch which has an opening of 19ft. 6in. by 20ft. One unloading conveyor is apportioned to six hatches, and the vessels are so loaded that the conveyor in the forward hatch No. 1 can be used exclusively for cement in bags; those in hatches 2 and 3 for cement in barrels; that in No. 4 for bags; and those in Nos. 8 and 9 in barrels. The cement in bags is conveyed to the pier for loading into freight cars for transportation by railroad to the locks at Pedro Miguel and Miraflores, or to any other point where it may be required; while the cement in barrels is conveyed to barges alongside the ships for transportation by water to Gatun. I mention these facts in detail to demonstrate the care and precision with which every little arrangement has been thought out and carried into effect.

As to the plant itself, the conveyor unit is arranged for bags or barrels. That for bags is composed of three parts:—(1) A vertical elevator for raising the bags of cement from the hold to the deck of the ship, consisting of a vertical shaft on which revolves an endless chain of brackets; (2) a portable apron-conveyor, at right angles to the ship, built in sections 20ft. long, which conveys the bags from the deck of the ship to the pier, and which has two towers for adjusting the aprons as the vessel lightens and rises upon being unloaded, there being a difference of 12ft. between loaded and empty draughts; (3) a stationary apron-conveyor, built lengthwise on the pier, which delivers the bags to any point along the railroad track. The conveyor unit for barrels is composed of two parts:—(1) A vertical elevator, the same as in the unit for bags; (2) a barrel lowerer with an adjusting tower, which conveys the barrel of cement from the deck of the ship into the hold of the barge alongside. Hand labour is required at three points—in placing the bags or barrels in position on stationary brackets, situated on each of the three decks of the hold, so that the brackets of the vertical elevator can raise them; on the pier, in transferring the bags from the stationary conveyor to the freight cars, and in the hold of the barge; and in removing the barrels from the lowerer and stowing them away.

Each vertical elevator in the conveyor system is operated by a 10-horse-power electric motor, each barrel lowerer by a 5 horse-power motor, and each section of the stationary apron conveyor on the pier by a 7½ horse-power motor, making a total of 20½ horse-power for each bag conveyor unit and 15 horse-power for each barrel conveyor unit. All the motors are totally enclosed, and are dust and moisture-proof. Electricity for the motors is supplied from the Gatun plant.

A word may be said as to the amount of concrete which is being used for constructing the locks at Pedro Miguel and Miraflores. The total for the first named is 916,166, as compared with 922,600 cubic yards given in the estimates for 1908. The total for Miraflores is 1,430,200, as compared with 1,328,300 estimated in the same year. The amount estimated for the spillway and dam at Miraflores is 75,000 cubic yards, as compared with 68,500 cubic yards estimated in 1908. The method of handling the material on arrival at the locks is shown by Figs. 24 to 28.

Concrete Barges.

A few weeks before I arrived upon the Isthmus there had been launched one out of a number of concrete barges which were being built, one at the time, upon the west bank of the Canal, nearly opposite Corrozál. These barges draw about 3ft. of water, and, when mounted with dredging pumps, the equipment weighs approximately 60,000 lb. All the barges are not of the same weight, since the second and third of the fleet weigh considerably less. While the construction of barges from concrete is by no means a new idea, its adoption is not known to have hitherto been attempted in American engineering. Concrete barges have been used successfully in Italy during the past few years, and recently the use of this material in the construction of floating craft in that country was extended to the building of transfer boats, a type of vessel similar to the New York car ferries. The barges in use on the Panama Canal differ in many ways from those made in Italy, however, and are distinct improvements upon them. Each of these former is 64ft. long by 24ft. wide, and has a depth of 5ft. 8in. The interior beams and columns have a spacing of 10ft. longitudinally and 8ft. transversely. Wooden forms were used in their construction, and the barges were launched sideways. Two interior longitudinal walls extend throughout with a bulkhead at each end, forming an interior compartment 40ft. long by 8ft. wide. The interior form was built in collapsible sections, so that the latter could be removed readily as the work advanced. The frames for the hull were constructed first, and the preliminary work consisted of the erection of supports on which wooden forms were placed. The wall construction consists of one layer of ¼in. mesh No. 12 wire cloth, ½in. transverse rods spaced 8in. on centres, and ½in. longitudinal rods spaced 12in. on centres, all securely fastened to the reinforced concrete framework above described. The side walls and bottom of the barges were then formed by laying on several coats of plaster made of Portland cement mortar and trowelled down to a hard surface. The plaster was laid on first from the outside, and an additional coat laid on from the inside, so as thoroughly to cover the ½in. mesh and steel rods. The decks of the barges consist of concrete slabs 3½in. thick, having spans 10ft. in length and 8ft. in width reinforced with ½in. rods both longitudinally and transversely. Wells are provided for pumping. The dredging pump motor and equipment, weighing approximately, as above stated, 60,000 lb., are placed near the middle of the barges, the maximum draught when loaded being about 3ft. The barges are easily moved about from place to place in the channel, each being equipped with four mooring bits, situated a few feet back from each corner, secured to the barge by long bolts embedded in the concrete of the side columns and diagonals.

Steam Shovels.

If one were asked which is the most important among the great variety of machines and implements in use upon the Panama Canal to-day, the natural reply would be in favour of the steam shovel, a piece of mechanism which is as fascinating to watch at work as it is wonderful in effectiveness. There are now a hundred of these machines either employed or ready for employment, and out of them all I have only heard of one which has come to grief permanently, that one being the 90-ton shovel which was wrecked by the disastrous explosion at Bas Obispo in December of 1908. Several shovels were flooded on one occasion; but on the whole there have been few accidents to these vitally important parts of the equipment. The records of work done by the machines is remarkable reading, and engineers may be interested in knowing the actual results of some of them in the Culébra cut. The best record is that of a 70 ton shovel working in the Bas Obispo section, which excavated 39,128 yards of earth in twenty-four working days. For one day the highest record is that of 4823 cubic yards place measurement of soft rock. The average amount

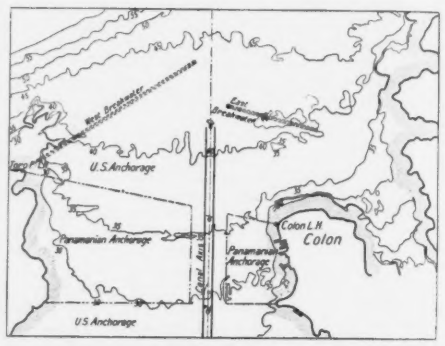


Fig. 23—BREAKWATERS IN LIMON BAY

of excavation per shovel per hour while actually at work is 289.1 cubic yards.

Naturally the question of repairs is a highly important one, and this is arranged in two manners—first, by sending the most seriously crippled shovels to be attended to at the splendidly equipped shops situated at Empire, and the other is to attend to the slightly disabled ones by "a field hospital" equipment. It is this latter which attracted my attention more particularly, and perhaps a brief description of the system adopted may be of interest. Five years' experience had shown the engineers of the Canal which of the frequent accidents to their shovel equipment should be treated on the spot and which should be sent to the Empire "hospital." A steam shovel is unlike a locomotive in that it seldom needs general repairs. One part will wear out or become weak, while the others are strong enough for several more months of service. Each part as it weakens is replaced by a new part, and in this way the shovels are practically rebuilt without going into the shops. Some of the shovels at present at work have not been in the shops for over two years, and appear sufficiently strong to stand the service for at least another year, and yet each of them has been extensively repaired by the travelling repair shop.

Careful watch is kept by the operator upon his machine, and when a part becomes weak it is not allowed to break, but is replaced by a new member. In the case of a weakened boom the shovel is turned over to the repair gang after the day's work is done. The boom will be loosened, the locomotive crane will lift it upon a flat car, and hoist a new boom into its place. After the boom has been lowered, there is a great amount of work to do before the shovel is ready to resume digging; but the men have thirteen hours in which to complete the job, and they never fail to turn a well-braced shovel over to the excavation gang in the morning. Replacing a dipper stick or handle is one of the most frequent pieces of important repairing, but this is also completed without any loss of time. About half an hour before leaving work in the afternoon the crew of the shovel commences to prepare the old stick to be removed, and another half-hour's work in the early morning will usually see their part done, and a new stick forcing the dipper or shovel into the earth or rock. During the night the repair gang has taken out the old stick and put in a new one. A swing circle or an "A" frame can be put in between sunset and

sunrise without taking the shovel from the bench or trench in which it is at work.

The largest field-repairing task is taking out a boiler and putting in a new one. Boilermakers, pipe-fitters, machinists, and labourers all work upon this, and frequently call in the blacksmith as well. After it is loosened on its foundations, and the connections between it and the engine have been cut, the boiler is lifted by the crane upon a flat car, and the new boiler, which is waiting, is taken from the car and set in its place. It is bolted to the floor, connected with the engine, fire is made, and when the steam shovel crew returns to work at 7 a.m., it finds that steam is up and the shovel is ready to dig. Naturally, such repairs cannot be made in an hour or two, time, skill, and patience being necessary. It often, indeed, takes more than one operation to carry out some repairs. It must be remembered that Culébra cut, where two-thirds of the shovels are in use, is nine miles long, and some repairs are necessary every day and night. The night gang of repairers is made up of thirty-one boilermakers, eight machinists, and a gang of labourers, and it is divided into three sections. The men in each section are distributed according to the demands of the work in the particular section. It frequently happens that several men will be at work on a shovel from 5 to 7 p.m., and on other shovels until midnight or later. Meanwhile, the crane will do its work at the first shovel, and, after it has left, the men will return to complete the job, and, by the excellent system of operations introduced here as elsewhere throughout the Canal organisation, it is possible to utilise most of the time of the men.

The night gang works from three to thirteen hours, and averages seven hours per night. The work is done in the open, sometimes under a clear sky, but often in drizzling or violent rains, and, again, in the complete obscurity of the heavy fogs which fill the Culébra cut at night during the rainy season. Boilers, booms, engines and other parts are swung into place by artificial light; bolts are drawn tight and pipes connected while the workman's face almost touches the lantern held close to his work. Yet there is no difficulty in keeping the men on night duty, and it is said that there is less illness among them than among the day shifts.

Dredgers.

Having given a description of the steam shovels which do such remarkable work on land, it is desirable to say something of their counterparts, the sea-going dredgers, which carry out similar work upon water. By the courtesy of the Chief Engineer, I was permitted to visit one of the dredgers and witness the whole of the operations. The equipment of the dredgers is in every way complete, and has been most carefully and cleverly thought out. There are two dredgers in work, known as the Ancón and the Culébra. They are large vessels, being 288ft. over-all, 47½ft. beam, and 25ft. deep. That they are capable of capital steaming is proved by the fact that one of them, the Culébra, came out to the Isthmus from Chesapeake Bay *viâ* the Straits of Magellan. Each ship is doing the work of eight good steam shovels and several dump trains, for an ordinary day's record is 15,000 cubic yards of material pumped from the prism. Each in itself epitomises the whole great work, for, like the towns and villages which have sprung up on the sites of the great territory of which the Canal forms part, these vessels are the homes and the workshops of the men employed, since they sleep, eat, rest and work there. Each of them has its quarters, mess-hall, machine shop, power-house, and tools for excavating; nothing is, in fact, wanting to make each of them a complete and self-contained establishment.

The Ancón is working in Limon Bay, from the point where the water is 45ft. deep in toward the shore. Here is being dredged a channel 45ft. deep at mean sea-level, and 500ft. wide. As the mud is pumped up into the bins, it is dropped out in deep water in the Caribbean Sea. A similar amount of work on land would make a big cut in a large hill, but nothing of the results of the dredgers' operations is visible to the eye. The measurements taken under water by the engineer in his cross-section calculations alone showinp the amount of work carried out from 1ft. to 30ft. below the adjacent bottom.

The Culébra is dredging at the Pacific entrance in the Bay of Panama, and here it is possible to see, when the tide is low, the actual channel which is being made, since the surrounding mud-flats rise above the water. In the first ten months of the vessel's work, she succeeded in excavating 3,862,794 cubic yards. It is quite fascinating to watch the dredger's operations, which can easily be done from the bridge. Turning into the channel near the end of the wharf, the dredger drops her two suction pipes, one upon either side of the ship, into the mud of Panama Bay, starting at the same time her 20in. centrifugal pumps, and all the time moving slowly down the prism of the Canal with two streams of mud rushing into each of her two large bins. Two men on the bridge, and under the eye of the watchful captain, turn the wheels that lower the suction pipes, or raise them as the contour of the bottom requires. This is one of the most important of the operations, for if the shoe at the end of the pipe rests too deeply in the mud the pumps will refuse to work; while, on the other hand, if it be raised a few inches too far above the bottom, little else but water will find its way into the mud-bins. From long experience, however, the "pipe-man" can tell by the feel of his wheel and the sound of the water falling into the bin, whether the shoe is in its proper place. The crew works in four-hour watches, each shift being on duty two watches a day, and some sixty men are employed. The pump-room, which is on the third deck, contains the engines, which work with great smoothness, and their noise is smothered in the great din created by the rattle and chug of the two large pumps as they draw up from the bay and force toward the mud-bins mud, rock, chain, and in fact anything that can pass through the 6 by 9 holes of the dredge shoe. Below the pump-room is another engine-room, where the twin screws of the ship are driven, and here also the noise of the pumps at work penetrates, and all other sounds are drowned. In the stokehold the temperature is 130 deg., and it is very difficult to obtain men to undertake the work there. The fuel in use is coal, although the floating equipment has an oil installation.

The spoil raised by the dredger is dumped on the mud-flats, situated about half a mile from the channel where the dredger is working. All the work is done by power, an engine turning the machinery that drops the bottom of each bin, letting the mud into the sea, and then closing the doors. When the spoil is disposed of, the ship turns back towards the docks; half an hour later the pumps are started, and the work of excavation is resumed *de novo*. Upon an average, the dredger makes ten trips daily, excavating over a distance of two miles, and upon each trip it makes two furrows in the bottom of the bay, each 5ft. wide. It is impossible to steer the vessel so that each successive furrow shall follow on and join up with its predecessor, but wave action and the cross cutting of the dredger tend to level the bottom, wearing off the high ridges and filling in the valleys. In some places the cut runs down 50ft. below mean sea-level, that is to say, 20ft. more than is necessary; but this is unavoidable, as dredging at the best is more or less blind work. The net result, however, will be a channel not less than 40ft. deep at mean tide, although in many places it may be deeper, since the capacity of the dredger, the Culébra, is that of 60ft. below her water line.

Nothing that is small enough to pass through 6in. by 9in. holes in the shoe can escape the suction of either of the two dredgers. The most favourable material is gravel, because it lies loose on the bottom, and the most difficult is heavy clay or rock. Solid rock cannot be excavated, but lumps almost as large as a man's head are carried through the suction pipes without doing any harm to them. Quite lately the dredger Culébra drew 10 fathoms of chain from the bottom of the Bay, and passed it through one of the centrifugal pumps without becoming entangled. A little while before that the dredger Ancón lifted a cannon ball from the bottom of Limon Bay. Fish, eels, shell, and rock pour into the bins so commonly that no notice is attracted by the occurrence. The crews of these dredgers are fine men physically, and in spite of the monotonous work which they are called upon to carry out, and the terrible heat which they have to endure upon the

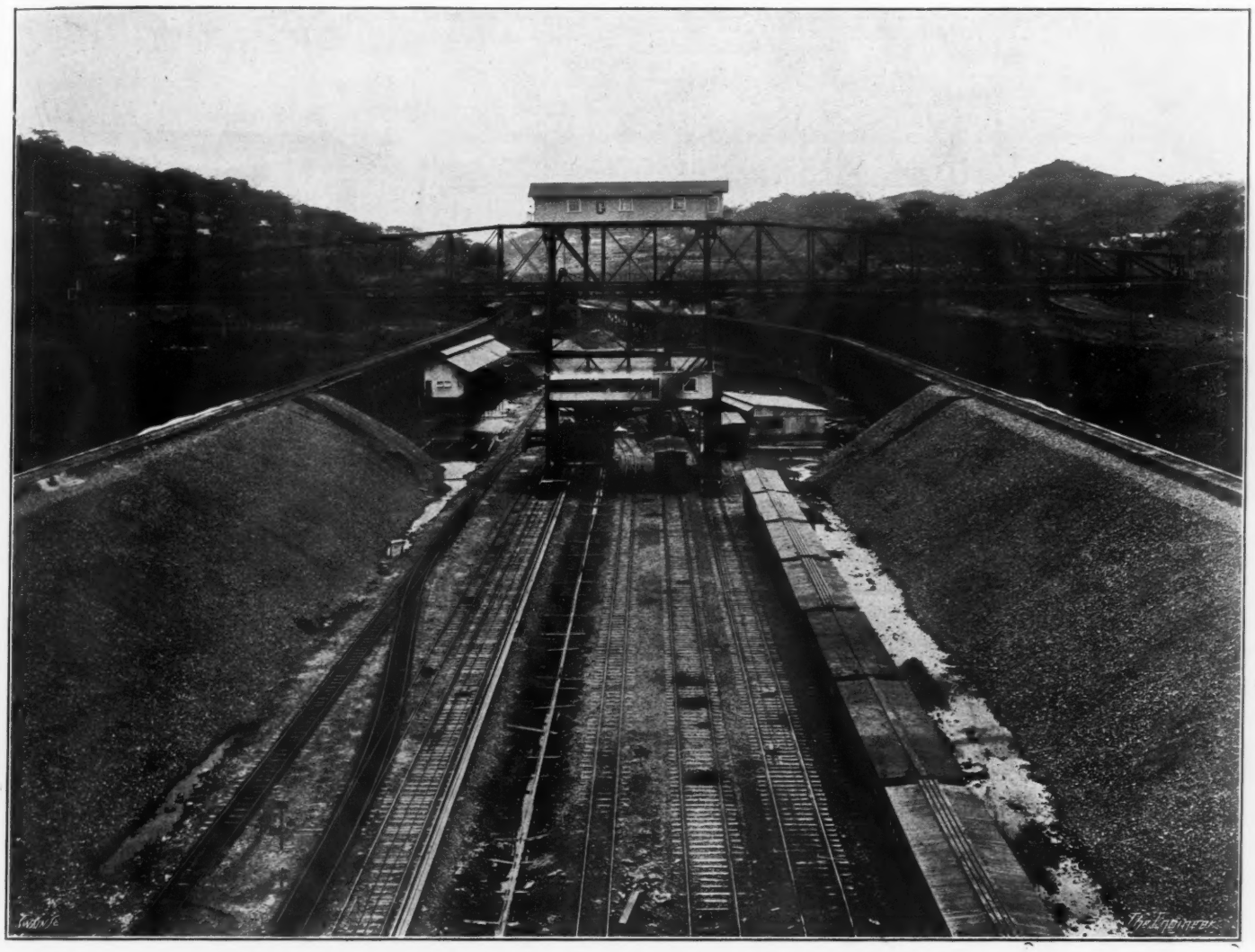


Fig. 24—PEDRO MIGUEL LOCKS, LOOKING SOUTH FROM BERM CRANE ROOF, SHOWING STORAGE TRESTLES—JUNE 13th, 1910

vessel at times, and especially in the engine-rooms and stokehold, they are a cheerful lot of fellows, and the best possible relations seem to exist between them and the captain.

The rations which they are given are unusually good, and the cooking also is far better than one would suppose. They enjoy four meals a day, at 6 a.m., 12 noon, 6 p.m., and, if they need it, at 12 midnight. The food in the forecastle is just the same as the food in the cabin, that is to say, it is both homely and plentiful, and the men are strictly temperate.

Compressed Air.

Compressed air is much in use upon the Panama Canal, and is employed as motive power for rock drilling and in the various shops, one system supplying air for the drills and the field-repair shops along the Culébra Cut, at Pedro Miguel locks, Miraflores locks, and for the well-equipped shops at Empire. Several small plants are distributed at convenient points along the Isthmus. The most complete and most important is the Culébra Cut system, which is the source of the supply for the immense battery of rock drills working here. It extends from a point about 800ft. south of the Chagres River, at Bas Obispo, to the newly erected field-machine shop at Miraflores Locks, a distance of approximately 13 miles. It parallels the Canal several hundred feet back from the slope line, far away from any danger arising from slides or blasting. The main line is made up of 38,000ft. of 10in. pipe, 14,600ft. of 8in., 10,000ft. of 7in., and 4000ft. of 6in. pipe, or a total of some 67,400ft. of pipe. From the mains air is conveyed to various parts of the Cut by "leads," which aggregate over 34 miles, composed of 110,000ft. of 2in. pipe, 5000ft. of 2½in., 9000ft. of 3in., 20,000ft. of 4in., 35,000ft. of 6in., and 600ft. of 8in. pipe.

For this large system air is supplied by compressors situated at Rio Grande, Empire, and Bas Cascadas. The first plant started was that at Rio Grande, on June 29th, 1906, where two Rand type non-condensing compressors were installed. These have duplex steam cylinders, 18in. in diameter 24in. stroke; air cylinders 18in. and 29in. in diameter, and 24in. stroke; while the capacity of each compressor is 2500 cubic feet of free air per minute. Steam, supplied from boilers taken from old dredgers, was in use until the end of 1907, when new boilers were installed. At the time the compressor air line along the Cut was commenced it had not been definitely decided what type of canal would eventually be adopted, and the sites of the plants were selected so that they would be adaptable to any type. While the Rio Grande plant was being built the main pipe line was laid. Several months later work was begun on the Empire plant, and both of these plants were completed before the Cascádas plant was commenced. The line was extended along the Cut as far as Las Cascádas, and the demands on the system soon became so great that it was found necessary not only to establish a plant at that place, but to double the capacity of the Rio Grande and the Empire plants. At the time of my inspection the Culébra Cut system consisted of three plants, each of which is equipped with two Rand type and two Laidlaw-Dunn-Gordon type compressors, with a total maximum output of 1,800,000 cubic feet of free air per hour. In the month of September last 315,081,000 cubic feet of air were compressed at three plants. In August the output totalled 328,988,000 cubic feet.

It is unnecessary to speak at length of the plants at La Bóca or at Porto Bello, since they offer nothing particularly noticeable; but a short account of the Empire shops equipment, the shop at Pedro Miguel, and the field-repair shops along the Culébra Cut, may, perhaps, be of some moment. It is to be observed that the Gorgóna shops—of which I shall have something to say later on—the dry dock, and the machine shop at Cristóbal, and the Cristóbal shops of the Panama Railroad Company, are all supplied with their compressed air by independent plants.

The fine installation of pneumatic tools used in all the shops on the Canal may be classed broadly as air-drills, air-hammers, and air-hoists. The drills are used in tapping, reaming and drilling holes in the steel plates,

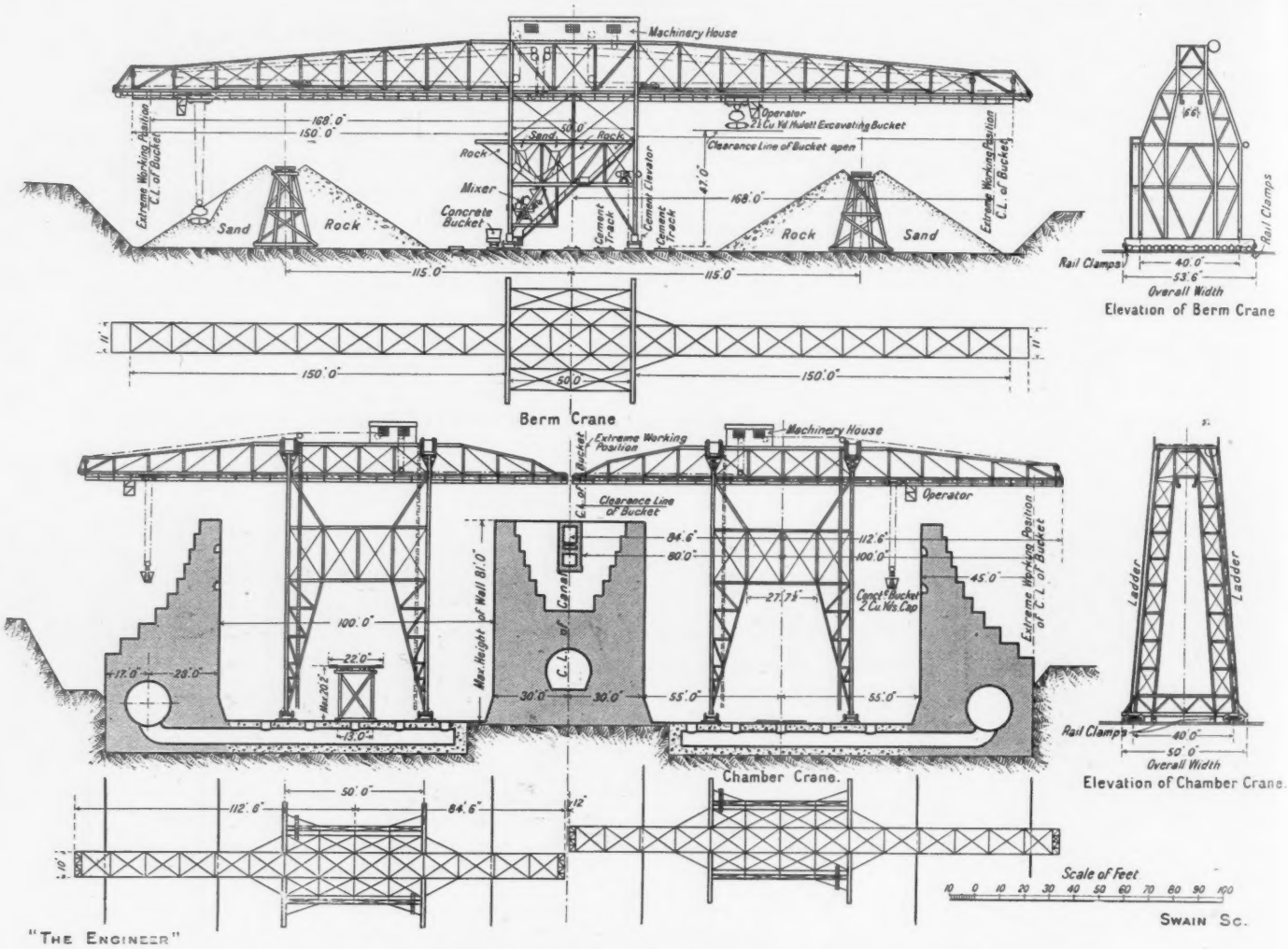


Fig. 25—GENERAL ARRANGEMENT OF MATERIAL-HANDLING CRANES, PEDRO MIGUEL LOCK

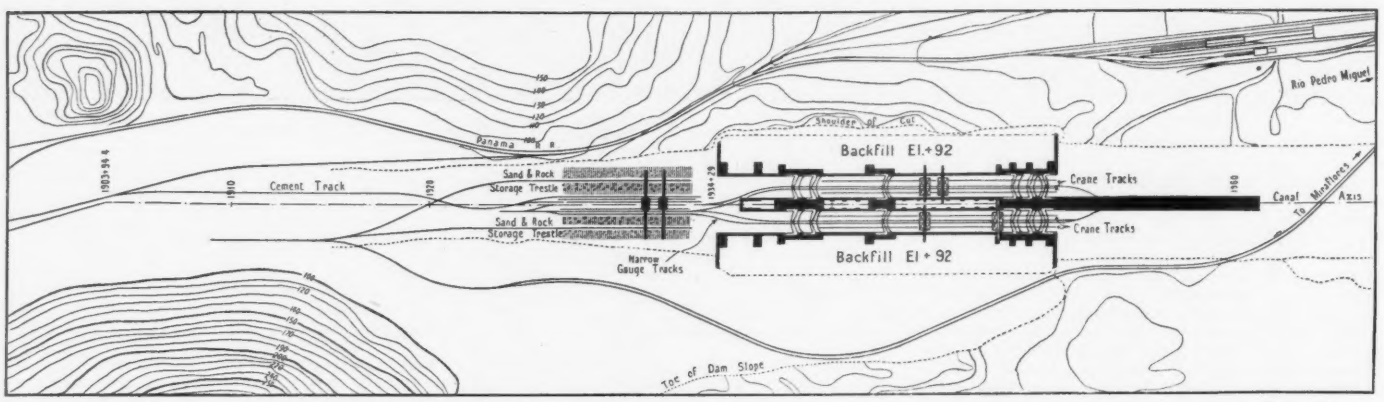


Fig. 26—LAY-OUT OF HANDLING PLANT, PEDRO MIGUEL LOCK

boilers, structural steel, &c., and also in boring holes of various sizes in all kinds of woods. There are in use on the Isthmus the "Little Giant" drills of various sizes, the "Thor" drills, Cleveland rotary breast drills, "Haeseler" drills and "Ingersoll-Sergeant" drills. In a recent test of the latter made at Gorgona shops, 54 holes $\frac{15}{16}$in. in diameter were drilled in 70 minutes through $\frac{3}{4}$in. boiler plates. To accomplish this by hand would have occupied 8 hours. At the same shops there are in use twenty-seven of these drills, twenty-eight at the Empire shops, three at Las Cascadas engine-house and shops, three at Pedro Miguel engine-house and shops, and one in the car repair shops at

Buéna-Vista, as well as a large number at other shops and shipways on the Isthmus.

Pneumatic hammers are being used for the purpose of driving rivets of all sizes, chipping, and caulking seams in boilers, beading flues, chipping castings, &c., and I may mention here that the steel parts of the Gamboa Bridge were put together by the use of these pneumatic hammers. Many thousands of feet of suction pipe for the dredgers have been built at the Gorgóna shops by the use of these hammers, and they have been likewise used to great advantage in the erection of fuel oil-tanks and some water tanks. At the Gorgóna shops there are in use forty-eight of these air-hammers, twenty-five at the Empire shops, three at Las Cascádas, three at Pedro Miguel, and two at the car repair shop at Buéna-Vista. Pneumatic hoists are used at different departments of the Gorgóna shops and at Empire, in handling heavy materials such as large castings, repair parts for steam shovels, machinery, &c., and there are sixteen motor-geared hoists and two straight lift hoists in use at the Gorgóna shops. At Empire there are eight motor-geared and thirteen straight lift hoists. An old French travelling crane has been equipped for some considerable time with air as its motive power, this crane being of 20 tons capacity. A great variety of other tools at all these establishments are also moved by air-compressors.

Gorgona Foundry.

Some particulars have been given above of the kind of work turned out by and the equipment found in the shops at Gorgóna, which may be regarded as the most important of the several establishments of this nature upon the Panama Canal. Although by no means the largest to be found in South or Central America, the Gorgóna shops are among the best designed and the best equipped that I have seen. They are now, and have for a long time been, a veritable hive of industry, over 1200 men being employed, while a night force has been placed at work in the boiler and machine shops, because the floor space, large as it is, is still inadequate to the amount of work which has to be got through. For the same reason night work is carried on in the blacksmith shop, for which a special force has been recruited. Naturally, the bulk of the regular work is on locomotive and car repairs, and in one month extensive repairs were made to 28 locomotives, 205 cars were rebuilt, 372 cars were lightly repaired, and field repairs were made upon 242 cars. At the outlying engine-houses, which are under the management of the Mechanical Division, 1828 running repairs were made to locomotives, 2782 light repairs to cars of all classes, and 8759 field repairs to cars; in addition, there were hostled 5344 locomotives, 349 cranes, and 182 pile-drivers and track-shifters.

When I visited the foundry it was undergoing a considerable extension, the increased demand upon its capacity having necessitated a lengthening by 145ft. and 18ft. more of width. The brass foundry was also being removed to another building especially prepared for it, namely, the former pattern shed, a new one being almost finished. By this arrangement some 3000 additional square feet of floor space will be gained by the foundry, while a concrete pit is being constructed near the iron cupolas, in which moulds for heavy castings will be made for the purpose of protecting moulds from water, which sweeps in during the time of floods. Near this pit, and swinging above it, will be erected a 10-ton jib crane, upon which ladles full of molten lead will be swung from the cupolas over the pit, and other moulds made near it.

The demand for grey iron castings keeps this foundry continually busy; but the largest piece of work in hand has been the casting for caisson seats in the locks, the orders on hand being no less than 722,000 lb. There were also awaiting execution orders for castings to serve as linings for Stoney gate chambers in the locks, amounting to another 1,791,000 lb. The foreman was also expecting an order to be sent down for 1,244,000 lb. of counterweights for the regulating gates in the spillway of Gatun Dam. The output of grey castings has averaged 460,800 lb. per month of late, for which a charge of three cents per pound is made, but as soon as the additional space is secured in the foundry it is expected that the output will be increased about 20 per cent. In the new brass foundry there are being installed three oil-burning melting furnaces. The output of brass and bronze monthly is now about 31,000 lb., for which a charge of 18 cents a pound is made. The prices quoted for brass and iron castings include the cost of supervision, plant charges, and all pattern-shop work. The monthly number of patterns may be put at 125 to 130.

Before leaving the subject of the foundry work, I think a few lines of description of the caisson seatings for the locks at Gatun, Pedro Miguel, and Miraflores, which were being made there, may be of interest. The castings are L-shaped, with stiffening webs, and are being placed on the ends of the walls and in the caisson sills at the upper and lower ends of all the locks, occupying a position such as the jambs and sill of a door. The primary object of these castings is to serve as a fill for the caissons that will be used at the head of the fore-bay in case it becomes

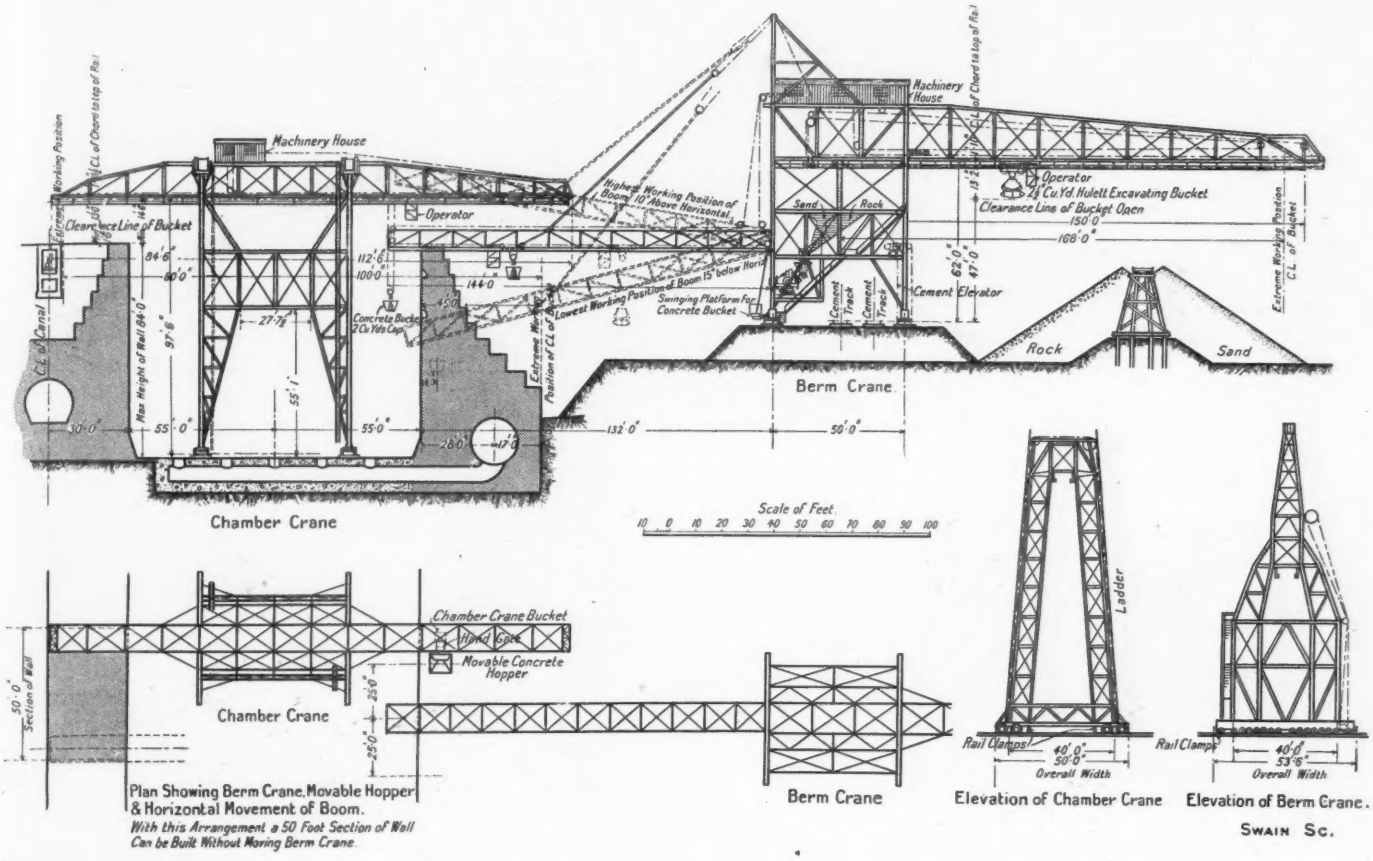

Machinery House
Operator
Clearance Line of Bucket
Concrete Bucket 2 Cu Yds Cap.
Chamber Crane
Scale of Feet
Berm Crane
Sand
Rock
Cement Elevator
Cement Track
Swinging Platform For Concrete Bucket
Lowest Working Position of Boom 15° below Horiz.
Highest Working Position of Boom 10° Above Horizontal
2¼ Cu Yd. Hulett Excavating Bucket
Clearance Line of Bucket Open
Chamber Crane Bucket
Movable Concrete Hopper
Plan Showing Berm Crane, Movable Hopper & Horizontal Movement of Boom.
With this Arrangement a 50 Foot Section of Wall Can be Built Without Moving Berm Crane.
Ladder
Rail Clamps
Overall Width
Elevation of Chamber Crane
Elevation of Berm Crane.
"THE ENGINEER"
SWAIN Sc.

Fig. 27—GENERAL ARRANGEMENT OF MATERIAL-HANDLING CRANES, MIRAFLORES LOCKS

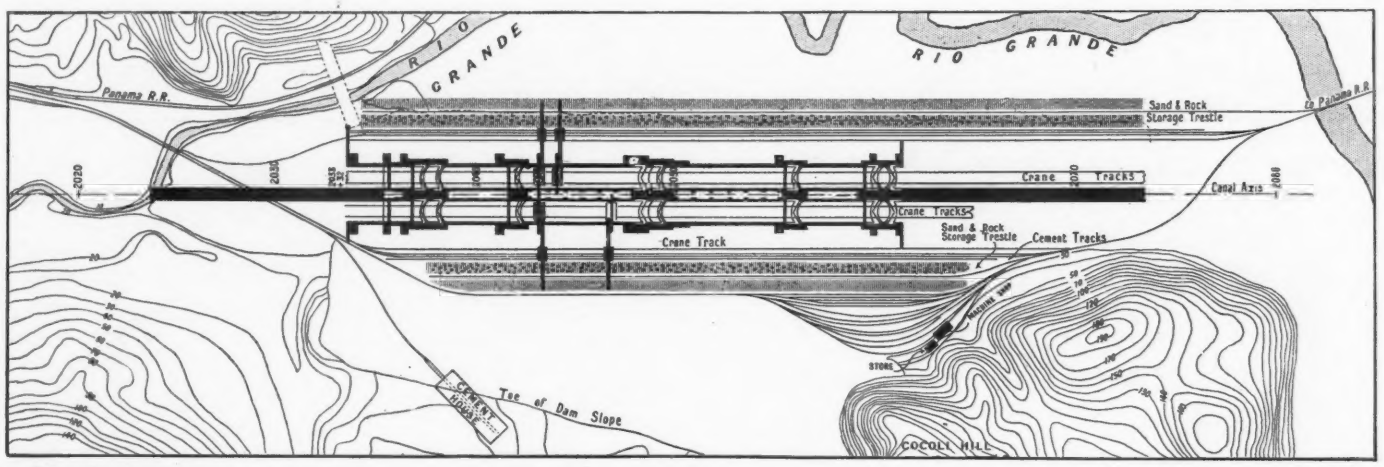


Fig. 28—LAY-OUT OF HANDLING PLANT, MIRAFLORES LOCKS

necessary to unwater the lock for examination or repairs. They will act as a guard to the movable dam, and will permit examination of the fill of the latter. It is unnecessary to provide these castings for each lock flight, as they can be towed from place to place. It is considered that two will prove sufficient for the entire Canal. They are to be provided with air chambers, which will be filled with water when it is desired to sink them in place. When at the proper point in the entrance to a lock, a caisson will be turned so that it will lie across the channel with its ends resting against the cast iron seats, after which water will be let into the chambers. A dam will thus be formed across the end of the lock. The castings, to which I have referred as being made in the Gorgóna shops, are intended to cover the ends of the walls, and to form a sill in the floor against which the caisson will rest when in place, and where it will be held by the force of the water which it is excluding from the lock chamber.

The greatest pressure to which these castings can possibly be subjected under the prevailing conditions is about 500 lb. to the square inch, and this would be possible only at the angle between the wall and floor of the lock, and provided that the floor seats or sill took none of the stress. The castings have been designed to resist this maximum pressure. In general they are 3ft. wide on each face, and increase from 1in. to 2in. in thickness, as the pressure increases from top to bottom. The castings are to be anchored to the concrete by means of wrought iron bolts running about 4ft. into the masonry, and attached to the stiffening webs. The number of the bolts varies with the size of the casting. The castings are being made from the regular grey iron used at the Gorgóna foundry, consisting of French and American scrap graded with American pig. The work is being done in connection with the other foundry work, and deliveries will be made as the material is needed.

Another interesting piece of work proceeding at this foundry is the manufacture of collapsible steel forms for the locks at Gatun and the "D" street sewer in Colón, an undertaking which is the most elaborate that has yet been entered upon. Four of six 90 deg. elbow forms, intended for the connections between the culverts in the floor of the locks and the main culverts in the centre wall have been completed. These forms are elliptical in section, and are built on a 19ft. 3in. centre line radius, the elliptical diameters being 6½ft. and 8ft. They are made of ¼in. steel plate, and weigh 13,000 lb. each. Delivery has been made of most of this order, which is for eighteen collapsible steel forms for the Cólon sewer. Each of these forms is 10ft. long, circular at the bottom and rectangular at the top, and from 5ft. to 7ft. 10in. in diameter. A number of collapsible steel manhole forms for the sewer have also been made in these boiler shops. Additionally, work is proceeding here upon twelve 4-ton derricks, to be erected upon the steel towers of the side wall forms at Gatun Locks for handling the girders that are a part of the wall forms. Two derricks are being erected upon each tower, and they will be worked by an electric hoist. The boom of each is a 40ft. stick, and the rest of the derrick is of structural steel. Other pieces of work in process of manufacture were pontoons and pipe for the 20in. suction dredges, and automatic measuring tanks for the concrete plant at Gatun. The output of the boiler shop per month may be said to amount to 300 tons of structural steel in new work, as well as much repair work of different kinds. The smiths' shop was equally busy, all its 18 coal fires going at the time, as well as a coke furnace used in the manufacture of locomotive springs and similar work, and nine furnaces using crude oil as fuel, two of which are designed for heavy forgings.

Power Plant.

The remaining space at my disposal cannot perhaps be better utilised than on a brief description of one of the several power plants to be found upon the Canal, namely, the Pacific Division Central Station at Miraflores. The building is now completed, and the equipment, which was begun in June, 1909, is one of the finest to be found on the Isthmus. The power-house is 157ft. 6in. by 76ft. 6in., and has a 14ft. basement. The eaves are 39ft. and gable 41ft. from the ground floor, and there is a 3ft. parapet surmounting the outer walls. The entire structure is of reinforced concrete construction, with the exception of one end and the portion of the turbine-room floor, where the switchboard and rotary converters are installed. On account of proposed changes and probable installation of water-turbines after construction of the locks, one end and the floor above referred to have been constructed so as to be easily removed. An 8in. centre wall, running the entire length of the building, separates boiler and turbine-rooms. At one end of the boiler-room is a gallery supporting the stack induced-draught equipment, and the oil-filtering and storage tanks. Surrounding the outer walls of the boiler-room, about 17ft. from the floor, is a concrete canopy, extending out 11ft.; below this the panels are left open. By this means excellent light and ventilation are secured. The circulating water intake and discharge tunnels are placed under the basement floor, and are of reinforced concrete.

The boiler equipment consists of six nominally rated 400 horse-power water-tube boilers, manufactured by the Keeler Boiler Company and arranged in batteries of two. They are equipped with Foster superheaters designed to give superheat of 150 deg. Fah. Each boiler is guaranteed to evaporate 17,000 lb. of water per hour from a feed-water temperature of 210 deg. Fah. at a pressure of 205 lb. absolute, and 150 deg. Fah. superheat. When working under these conditions with 1 oz. induced draught, with a grade of coal having a fuel value of 14,000 B.Th.U. per pound, the guaranteed thermal efficiency is 65 per cent. The furnaces are designed for the use of either coal or oil, and are equipped with shaking grates and Best Company oil burners. The induced draught equipment consists of two 90in. duplicate fans, situated in the bottom of a steel stack. One is driven by a vertical cross-compound steam engine, and the other by a 100 horse-power 220-volt three-phase induction motor. The feed-water heater is of the open type, and is guaranteed to heat 80,000 lb. of water per hour from 100 deg. Fah. to a temperature of 205 deg. Fah. when supplied with 80,000 lb. of exhaust steam for non-condensing auxiliaries. The two feed-water pumps are capable of delivering 200 gallons of water each per minute at a temperature of 205 deg. Fah. against a discharge pressure of 225 lb. when supplied with steam at 175 lb. gauge pressure, and superheat of 150 deg. Fah. A motor-driven compressor supplies air to the pump air chambers, and for blowing out machinery.

The electrical equipment consists of three 1500-kilowatt 2200-volt three-phase, 25-cycle turbo-generators, with base condensers, two 35-kilowatt 125-volt turbo-exciters, one 30 kilowatt 125-volt induction motor-driven exciter, and all switchboards and switching apparatus being furnished by the General Electric Company. The turbines are of the Curtis vertical type. Their guaranteed steam consumption is 17.6 lb. per kilowatt hour, when working at 100 per cent. load, with 150 lb. gauge pressure, 140 deg. Fah. superheat at throttle, 2in. absolute back pressure. The condenser equipment for each turbine consists of one 3500 square foot surface condenser, one engine-driven centrifugal circulating pump, one dry vacuum pump, and one hotwell and hotwell pump. In addition, there has now been installed for service during construction of the locks two 500 kilowatt 600-volt, and one 300-kilowatt 600-volt rotary converters. These have been placed in a temporary portion of the building. The two 500 kilowatt rotaries are at present situated in the sub-station at Pedro Miguel, but it is intended to install them later on in the power-house in order to furnish power for construction work at Miraflores. All alternating-current switches, generator field-switches, turbine governor control-switches, and generator field rheostat control-switches are controlled from a three-section bench-board. On each section of the bench are mounted the following control switches, with indicating lamps:—One generator switch, one rotary converter switch, one bus-tie switch, four outgoing feeder switches, one generator field switch, one turbine governor control-switch, and one generator field rheostat control-switch. On the upper vertical section of this board are mounted the indicator instruments, and upon a three-panel vertical board in the rear of the bench-board are mounted the recording instruments and time limit relays. The exciter board consists of three exciter panels and two Tirrill regulator panels. The railway, or 600-volt. board consists of three rotary converter panels and six feeder panels. All panels are of black slate. Along the west end of the turbine-room are placed all the oil switches. These are solenoid operated, G.E., type K, Form 3. There is also a 300-kilowatt rotary converter installed at Balbóa to furnish power for the sand unloading cranes. In the turbine-room a 20-ton overhead electric travelling crane is installed.

FIG. 29—SITE OF THE UPPER LOCKS, MIRAFLORES, LOOKING NORTH

Concluding Remarks.

When the Canal shall be pronounced completed, and the huge lock-gates swing open for the first time to receive the earliest vessel, a chorus of acclamation and congratula-

tion will ascend such as probably no human achievement has ever yet called forth. And justifiably so.

In the general satisfaction which will be felt and expressed at the consummation of this remarkable enterprise, it may be hoped that those who have worked and have departed will not be lost sight of, nor a tribute be lacking to the many hundreds of loyal and zealous men who gave their lives to the great undertaking. Thick are the graves of such upon the Isthmus of Panama, and not without reason has it been said that every foot of progress made upon the Canal has signified a man's life. Also there are those, while still happily among us, who are no longer factors that count in the colossal enterprise upon which once they were engaged.

It must not be forgotten that it was in the earliest days of the project that the severest and the most exacting part of the work was done, when money was lacking, when criticism was withering and foul disease was rampant, when neither energy nor encouragement, neither hope nor help were extended to the men who were sweltering and dying in hundreds under a pitiless sun in a death-laden climate. And yet they, who survived, persevered, so that when the Americans came in 1904 to take up the labour, where it had been dropped for lack of funds, they really found that the worst had been accomplished, or almost so, and with the experience and the exertions of their predecessors to guide them, with the whole wealth of the the United States behind them, and with the immense resources of latter-day science to help them, they found their labours much lightened and their prospects correspondingly strengthened. Let this not, I say, be overlooked, nor, in the enthusiasm of the moment, while applauding the living, let us forget the dead.

Date of Completion.

Many individuals have permitted themselves the privilege of prophesying when the Canal will be finished, independently of the official estimates, among these being Mr Herbert R. Squiers, United States Minister to Panama in 1909. He was "quite sure" that the end would be witnessed in 1913; but the more conservative and more authoritative estimate is given as 1915. The amount of progress made is certainly not suggestive of any better attainment than this, which, if reached, will be deemed good enough. The second year of the work saw the first year's record trebled, and that of the third was more than trebled. In the fourth year the record of the third year was nearly quadrupled, and in the fifth year there was an increase of more than 50 per cent. over the record of the fourth year. Now, in all probability the sensational records of increase will stop, and the rate will be more conservative, although still appreciable. The completion of the Culébra Cut may well be accomplished by 1912 or 1913; but this is far from being the end of the work. The great feat consists in the construction of the Gatun dam and locks, and it is these which will determine the factor of completion. I believe that the end of 1914 will see this stupendous undertaking accomplished. The four great stages of construction have been:—(1) Sanitation; (2) rebuilding of the Panama railroad; (3) excavation of the Canal; (4) and last, the building of the Gatun dam and locks, as well as the locks at Pedro Miguel and Miraflores. To all human sight it would appear as if nothing now could interfere with the successful completion of the undertaking, but we should all the same remember Browning's warning, "Measure not the work until the day's out and the labour done."

The Administration.

Great enterprises of a national character as often as not form the graves of great reputations, and it has been the case with the construction of the Panama Canal. This proved so with the great De Lesseps and many of his associates. But with the Americans things have been somewhat different, for many a man who had been hitherto obscure has come into prominence through association with this undertaking; and some of the engineers connected with it have secured a world-wide reputation. The man who will, and who is entitled to, receive the greatest amount of praise, is Colonel George W. Goëthals, Engineer-in-Chief of the Isthmian Canal, although he will probably be the last to admit this. I do not say that he is entitled to the greatest honour, because he is, or may be, able to see it through its trials, to emerge in triumph as an existing enterprise. I say so because he of all men has persistently, patiently and pluckily adhered to his post in the face of bitter criticism, of hostile and fractious opposition among some of his own employés, and in the teeth of the unfriendly attitude shown towards him by more than one of the Commissioners who have sat with him on the Board. Only a strong man, and only an honest man, could have withstood the strain to which he has been subjected, and only a very able man could have come out successfully from the sea of difficulties and contretemps which have been the lot of the engineering staff almost from the commencement of their labours.

Well, Colonel George W. Goëthals is all this. He is, moreover, an upright man, and one of the most humane and just administrators with whom I have come in contact. There are many individuals, I care not to what nationality they may belong, who, finding themselves placed in a position of so much importance as that of Chairman of the Isthmian Canal, which means being the arbiter of the fate and the existence of some 40,000 souls, might have abused their power, and either have acted the tyrant or have neglected the minor duties of their exalted position. Without some personal experience of the Canal administration and the manner in which it has been undertaken, no one can form an adequate idea of what this almost despotic system of government has meant to the thousands of human beings, white and black alike, living upon the Isthmus. In the hands of the Chairman has even been reposed the granting or withholding of life; for he has been privileged to reprieve a prisoner under death sentence, or to release a convict who has been condemned to perpetual imprisonment. But whether it has been a question of this magnitude or one of merely granting a humble labourer sick leave, Colonel Goëthals has always brought the same care, the same patience, and the same clear intelligence to bear before deciding, with the result that there is not a man or a woman upon the Isthmus who has not the fullest confidence in and the greatest esteem for the Chief, who, elevated as he is above them by reason of the position which he holds, is yet of them, sharing their pleasures, relieving their sorrows, and giving ear to their complaints, no matter how trivial they may be nor how often they are urged.

It has been my privilege to be in the company of Colonel Goëthals while he has been upon his daily rounds, as well as in his office, and I can therefore speak from personal experience of his keen penetration, of his extraordinary grasp of detail, of his calm and well-balanced judgment, and, above all, of his great kindness and sympathy towards those who call for his consideration. The Chairman has not permitted himself to occupy a pedestal which none but the privileged may approach; nor will he countenance the introduction of that bane of all authority—the intervention of the sub-official. He is there to attend to the requirements of the *personnel* of the Canal staff, and be he high or be he lowly, be he an official or merely a common labourer, his ear is open to all complaints and his attention given to all suggestions. Anyone may come to him; no one is ever denied. Sundays are the days which he devotes to listening to grievances, and among a population of nearly 40,000, some of whom may be considered the dregs of humanity, black and white, it may be believed that the task of listening to, and adjudicating upon, these matters is no light one. Colonel Goëthals often takes his meals in the men's canteens, and he then eats their food and pays for it as they do. He asks them to do no more than he himself does in his own sphere of action; but he asks no less than the performance of their duties in the same loyal and earnest manner as that which characterises his own performance.

When the history of the Canal and its builders comes to be written a high position will be accorded to Colonel George W. Goëthals, whose efforts and example have reflected as much credit upon him as they have redounded to the success of the enterprise.

Lieut.-Colonel H. F. Hodges, who during the absence of Colonel Goëthals in the United States, has acted as Acting Chairman and Chief Engineer, is an officer of great distinction. His enthusiasm for his work is undoubted, and he has brought to bear upon his many difficult and responsible duties a clear and far-seeing judgment which has helped to solve many an apparently hopeless problem. Lieut.-Colonel Hodges is one of the most able engineers of the day.

An official who has rendered, and is rendering day by day, great service to the administration of the Canal is the secretary, Mr. Joseph Bucklin Bishop, whose department may be considered as one of the most important and responsible on the Isthmus. Mr. Bishop, like a great many other officials, not excepting the Engineer-in-Chief, Colonel Goëthals, has been subjected to many hostile and ignorant criticisms, and, indeed, so bitter have been the cabals against him in the United States, entirely of a political nature, that his official salary has actually been cut in half. Nevertheless, Mr. Bishop has continued to work loyally and unceasingly for the Commission, and the immense amount of detail which his department has to handle would appal an ordinary Government official in any other country, our own not excepted. Mr. Bishop is a man of charming manner and of culture. He abandoned a lucrative editorial position to assume the duties of Secretary to the Canal Commission, and since he has occupied it he has created the most favourable impression among all with whom his department has had relations.

Past Officers.

Among those who will be remembered, even though they be no longer active factors in the great undertaking, are Mr. John F. Wallace, who was Chief Engineer from June 1st, 1904, to June 28th, 1905, and under whose able supervision sanitary works, water supplies, &c., were undertaken; and Mr. John L. Stevens, who served from July 1st, 1905, to April 1st, 1907, and during whose administration yellow fever broke out, and caused practical abandonment of the work for nearly two whole years; and others, if not so eminent, at least as loyal and as energetic have, or should have, their names inscribed upon the list of those who have helped to make this great waterway.

Organisation.

Not the least remarkable part of the Canal enterprise has been the system of organisation, which has been one of evolution, since the earliest days were characterised by little of the extreme orderliness and attention to detail which have been observable, say, within the past three years. The general organisation may be said to consist of the following:—The Office Staff, the Central Division, the Atlantic Division, the Pacific Division, the Secretarial Department, the Mechanical Division, the Chief Quartermaster's Office, the Subsistence Department, the Civil Administration, the Chief Sanitary Office, the Disbursing Department, the Examination of Accounts Office, and the Panama Railway. There is also the Washington General Purchasing Office.

Commissioners.

The Canal Commissioners, all of whom have been appointed by the United States Government and the President, are seven in number, independently of the Chairman. The names of the Commissioners are:—Colonel George W. Goëthals (Chairman and Chief Engineer), Colonel C. W. Gorgas (of the Department of Sanitation), Lieut.-Colonel H. F. Hodges (Assistant Chief Engineer), Major Wm. L. Sibert (Division Engineer of the Atlantic Division), Lieut.-Colonel D. D. Gaillard (Division Engineer of the Central Division), Mr. H. H. Rousseau (Assistant to the Chief Engineer), Mr. J. C. S. Blackburn (of the Department of the Civil Administration), and Mr. Maurice H. Thatcher, who was appointed as recently as April of 1909. The annual remuneration of each Commissioner is at the rate of 14,000 dols., say, £2800, effective from the date of sailing for the Isthmus, the use of a furnished dwelling-house on the Isthmus, as well as actual and necessary expenses while away from the Isthmus upon official business. It will be seen that each Commissioner, with one exception, has his own particular departmental work to attend to besides his Commission duties; these are really of a light character, being more consultative than operative, since it is the Chairman and his immediate staff of assistants who do all the principal work of administration. The Commissioners and the Chairman have not always seen eye to eye upon some matters, and the divergence of opinion has sometimes been so acute as to threaten dissension. In all probability this would have broken out but for the tact and determination of the Chairman, whose task, nevertheless, has been far from agreeable upon more than one memorable occasion. There are those who have pronounced Colonel Goëthals autocratic and dictatorial; but there are no such critics to be found among his immediate colleagues, who have found him of a firm mind but by no means impervious to argument.

The Quartermaster's Department has charge of the recruitment of skilled and unskilled labour, and the care and assignment of all quarters, together with furnishing them, distributing fuel, commissary supplies, and distilled water.

The Commissary and Subsistence Department was formerly under the control of the Panama Railroad Company, but in the month of July, 1908, it was transferred to the charge of the Subsistence Officer of the Commission, and is managed in conjunction with the hotels, messes, and kitchens. The magnitude of the business done can be gauged from the fact that in the year 1908 the sales amounted to 4,841,647 dols., while for the year 1909 they amounted to almost 5,000,000 dols. The department is of no expense to the Commission, but is operated at a small profit, such profits going to the account of the Panama Railroad, and being used for the erection of new buildings. Besides the Tivoli Hotel, a building which for comfort and elegance will vie with any establishment upon the Continent of Europe, there are seventeen hotels, nineteen messes, and twenty-one kitchens, providing food daily for nearly 8000 people.

The Examination of Accounts and Disbursements Department was entirely reorganised in October, 1908, the Examiner now performing, in addition to his ordinary duties, a number of others which had formerly been the concern of other departments. He has charge of the books, the classification of the expenditures and statistical work, the handling of bills due to the Commission, the accounting for coupon books and meal tickets, the handling of claims and accounts, examining and checking time, superintending the pay rolls, and a number of other important duties.

The Disbursing Officer, who is attached to the same department, in addition to securing disbursing and accounting for all funds paid out or collected, is charged with the care and issuance of hotel and commissary books and meal tickets, as well as a number of other equally onerous duties. The staffs of both these sections are very large, and the auditing of the various accounts a monumental task. But it is carried out with the same perfection of detail which characterises all the remaining branches of the Commission's business, and I was informed that the books are balanced each day with the same care and correctness as the books of a bank, with the same exactitude and almost the same rarity of an error being made. Owing to the system in force, the embezzlement of money or overcharges are very difficult of accomplishment. I will not say that no such occurrences have been known, but considering the gigantic sums handled, and the immense number of channels through which they flow, to say nothing of the different characters of the individuals employed in the various departments, the number of defaults is remarkably few.

Labour.

What has caused no little surprise among engineers and contractors alike has been the apparent smoothness with which the Canal labour has been recruited and managed; but to those alone who are acquainted with the inner working of the undertaking has it been clear at what a sacrifice of dignity and calmness has this same "smoothness" often been attained. As a matter of fact, the labour question is one of almost daily concern to the Canal authorities, for they have to deal with a class of man who is at once competent and independent, assertive and frequently insubordinate, the true type of aggressive American skilled workman. The authorities are under strict injunction to use pacific means upon all occasions, and upon no account to precipitate a strike or a general disturbance. Time after time the good sense and the self-restraint of the higher officials have prevented some such occurrence, and it is worthy of record that up to now the work upon the Canal has only twice suffered serious interruption owing to a strike, and in all probability the repetition of such a deplorable contingency will be obviated to the last. The men are, however, extremely difficult to deal with, and have to be handled with the utmost care and discrimination.

Practically all the labourers, who are divided into two different classes, known as the "silver" and the "gold" employés, the first, because they are paid in the coin which represents the currency of the country, are foreigners, and are recruited under arrangements with their respective Governments, whose agents on the Isthmus exercise close supervision over their welfare. Seventy-five per cent. of the labour is West Indian, and

over this the British Minister, Mr. Claude C. Mallet, C.M.G., has jurisdiction; but I have it upon that gentleman's authority that a general feeling of contentment prevails, and that the number of complaints of ill-treatment or abuse made to him is very small considering the number of hands employed. As a fact, the supply of labour is considerably in excess of the demand, and, while at one time it was a matter of the greatest difficulty to obtain the required supply, to-day there are hundreds of negroes waiting a chance to go on.

The most of the trouble which the authorities have to face is that emanating from the "gold" employés, whose remuneration is reckoned in American gold dollars. These men, who are divided into the clerical and the engineering classes, are mostly members of some trade union. In fact, all workmen such as those running stationary engines, steam shovels, traction engines, or fitters, moulders, carpenters, &c., are members of such unions, and naturally every effort is made by the responsible authorities to avoid a clash with any one of them. There has been, as I have said, but two strikes, and it is the object of all alike not to have another. The second strike took place as recently as last March, but it was so promptly and so energetically handled by Colonel Goëthals that its duration was actually extended to but two or three days, and in the end the dissatisfied men went back to work without having gained a single one of the points which they had demanded. It is known, however, that the strike leaders in the United States are longing for an opportunity to assert their somewhat waning authority, and in the Canal works they can see a particularly vulnerable spot in which to strike at the Government and employers at the same time. It will need all the art and all the tact of the Canal Commission and their officers to avoid a collision now and in the future.

At the commencement of this article I candidly expressed the feeling of admiration with which I have regarded the organisation and the actual work carried out on the Canal. I agree with ex-President Roosevelt when he said, in his famous message respecting this enterprise, "The wisdom of the Canal management has been shown in nothing more clearly than in the way in which the foundations have been laid." That has been the one conviction which has impressed me also, as it must have impressed any impartial critic who has expended any time and thought upon the project. When one remembers that every foot of lumber, every bit of machinery, every tool, every nail, every pound of paint, every skilled mechanic, every railway sleeper and rail, every locomotive, flat-car and dump-car, every piece of furniture, every bit of plumbing material, and virtually every ounce of food had to be brought 2000 miles from a base of supplies; when towns and villages had to be built under these conditions; when a decrepit single-track railway had to be enlarged and converted into a modern double-track, serviceable road without interrupting the traffic for a single day; when docks had to be constructed to accommodate the enormous amount of traffic arriving hourly at the Isthmus; when every piece of machinery, every locomotive and car, every crane for the docks had to be set up in the United States, subsequently taken apart, transported 2000 miles, and then set up again on the Isthmus; when waterworks had to be built and a system of sewerage completed before white men could reside with any safety on the ground—when all this had to be done, and done well, it is no less than a triumph to have accomplished so much in so comparatively short a time.

Were I an American, I should feel genuinely proud of such an achievement; and I cannot understand any citizen of the United States not cherishing such a sentiment, even though the work be still far from the completion stage.

I speak of the undertaking as an engineering feat, and not as an enterprise of international commercial importance. In this light it will have to be judged when the time arrives. The one great question will then have to be settled whether the same brains which have solved the constructional problem will be able to deal with the even more difficult and more responsible task of administering it intelligently, and for the greatest good of the greatest number.

It has, naturally, been impossible in the space of this Supplement to do much more than give an outline of the enormous undertaking, and many of the technical aspects of the work have been left untouched in order to give a general view of the whole enterprise. But the progress of the work has been recorded by periodical articles in our pages, and as some of our readers may desire more information on certain points than is contained here, we give a list of references to past issues:—

The Panama Canal and Congress, March 3rd, 10th and 24th, and April 7th and 21st, 1905.

Progress at Panama, July 3rd, 10th and 17th, and August 7th, 1908.

Present Conditions at Panama, May 27th and June 3rd, 1910.

Machinery and Equipment on the Panama Canal Works, August 12th and 26th, 1910.

Excavating Machinery on the Panama Canal, September 2nd and 9th, 1910.

Locks and Dams of the Panama Canal, September 30th and November 11th and 25th, 1910.

Fig. 30—UPPER LOCK SITE AT MIRAFLORES LOOKING NORTH—JUNE, 1909

Fig. 31—GATUN DAM AND LOCKS FROM THE EAST, 1909

COST OF EARTHWORK IN LOWER EGYPT.

As is well known, the whole of Lower Egypt is covered with a network of canals which distribute the water of the Nile for the cultivation of the land. The Nile water carries a lot of silt, amounting in flood to about 1.75 grammes per litre, and in summer to a minimum of about 0.25 grammes per litre. In a perfect canal the velocity of water should be such as neither to scour the canal nor allow the silt borne by the water to settle and thus decrease the effective cross-section of the canal. But in Lower Egypt most canals have to carry a very different discharge in summer from that carried in flood, and yet the same cross-section has to serve for both. This is a fruitful cause of silt deposit. But even apart from this, canals will silt owing to sudden variation of amount of water drawn off by cultivators, and once a canal starts silting it is difficult to stop. Eventually the section will become so diminished as to be unable to carry its discharge. The silt must then be removed. The most economical way of doing this is to lay the canal dry and remove the silt by hand labour. Naturally, during this period, cultivators are deprived of water along the canal in question, so a time must be chosen when the crops can best dispense with water. In Egypt this time is from mid December to the end of February, and it is the habit to have a general closure of all canals for a period of forty days during this time. Forty days is the maximum time allowed, and should on no account be exceeded. The work is all done by men from the southern provinces of Egypt—Asyut, Girga, and Keneh—"Saidis." These provinces are irrigated on the basin system, and after the water is run off the basins in October, and the seed sown, the local fellahin have nothing to do till harvest time in April and May. Each irrigation circle divides the annual clearance work up into lots varying from 50,000 c.m. to 250,000 c.m. to be done during the forty days' closure. To these are added bank repairs which can be done after the closure, making the total cube of each lot from 100,000 c.m. to 500,000 c.m. to be finished some time in April. These lots are put up to public tender, and the contract awarded, normally, to the lowest tender. It is the object of this note to arrive at the rate per cubic metre which may be considered to give the contractor a fair profit. The chief considerations to be taken into account are not technical ones—for the work presents little or no technical difficulties—but considerations of the "Saidi" and the conditions under which he will work. The Saidi is not a very high type of the "Genus Homo." He is strong and usually cheerful, and at a pinch can work hard. He is densely ignorant and superstitious, but wily enough in looking after himself. As the result of many centuries of being swindled and oppressed, he trusts no one and tries to cheat everyone.

A contractor having been awarded a contract for earthwork, as above, has first to find his men. The men are collected from their villages by gangers, known as "Sawaqin," who make their living by it. No Saidi will leave his village without first receiving an advance varying from £E.1.5 to £E.3.* A fair average to take is £E.2 per man. A contractor, say, needs 125 men, and accordingly gives his "Sawaq" £E.250 to go and get them. After some delay 100 men appear, the "Sawaq" is left with £E.50 in hand, though he probably declares that he paid out the whole £E 250 and twenty-five men have not kept their word. This may be true or it may not. Anyhow the contractor loses his £E.50. The "Sawaq" promises he will bring the men down the following year, or pay back when he has sold his crops or something; but in effect the money is lost to the contractor. Of course the "Sawaq" has given a guarantee of some sort, usually in the shape of a mortgage on land, to the contractor, before the latter parted with his money, and the contractor could go through the courts and eventually succeed in getting the money back. But he dare not, for if he tried any such thing he would never be able to get another man for any work he needed, and also the courts are so congested with work that the case would take years before even it was heard for the first time. Contractors have to make up their minds to bear this loss. Eventually, when any particular "Sawaq" is very heavily in debt to them, they get a part back—that is to say, one year he will bring men down to the full value of the money received as advance. Most contractors have large sums outstanding in this way, amounting to many thousand pounds, earning no interest, and with a poor prospect of ever being recovered.

The railway fares from the Saidis' villages to the site of the work and back again are partly at the contractor's expense; it is usual for the contractor to pay about one-third. An average of this is 15 piastres (3s.) per man, there and back, for the Saidi is quite happy travelling in an open truck by goods train, with his sack of bread beside him, and the fare by goods train is half ordinary third-class fare. The Saidi having arrived at the site of the work, the rate per cubic metre at which he is to do the excavation remains to be settled. The Saidi has altogether the upper hand in this business, for he has £E.2 in hand and no scruples. The contractor, too, is not usually burdened with these; but he has deposited caution money with the Government as a guarantee to finish the work given to him within a certain time. So, by cajoling and flattering, alternated by threatening and swearing, he has to make the best price he can with the Saidi. He has to remember, however, that if he is too hard on the Saidis they will have no hesitation in leaving him—despite their having received an advance—and going to a contractor in a neighbouring lot, who, of course, is only too keen to get men to work for him who have received no advance from him. It is by no means uncommon for a contractor, having paid out £E.250 and got 100 men on the work, to find that they all have gone over to another contractor. He has no redress unless he chooses to bring 100 separate law suits, each for the recovery of £E.2, for the other contractor has merely offered free men 2 milliemes per cubic metre more to do certain work than the first contractor did—very laudable on his part, and in no way illegal.

In an ordinary canal of 2 or 3 m. width and about 1½ m. depth, with about 2 c.m. per metre length of clearance, each Saidi can remove about 4 c.m. per day and deposit it on the canal bank. The winter in Lower Egypt is cold enough to be disagreeable to the Saidi from Girga and Kenek, and he does not start work early nor keep on late. The Saidi expects to earn about 50 milliemes (1s.) per day; therefore, the minimum rate he will accept per cubic metre is about 12½ milliemes.

The closure lasts forty days, from the time the head sluice of the canal is closed to the time it is opened. The first five days of these forty at least are taken up in drying the canal. The contractor runs out as much water as he can through irrigating channels, &c., and then makes a bank at each end of the reach to be cleared and lifts out the remaining water with the native "shadoofs" (bucket on a lever) or "tamboors" (Archimidean screws). After the water is removed the silt has to dry a little, before the men can work in it. At a minimum computation work cannot begin till five days after the water is shut off. These five days are occupied in bargaining with the Saidis. There are 35 days left Now the Saidi insists on one day of rest per week—the market day at the nearest village. Nothing will induce him to forego this. Therefore out of the 35 days, 5 more are lost, leaving 30. Before the water is let into the canal again the work must be taken over by the Government—that is to say, it must be finished one day before the canal is opened—29 days left for work. In addition, in Lower Egypt during the winter, one must reckon an absolute minimum of two days of rain during this period—and when it rains the Saidi won't work—thus the effective working period is reduced to 27 days. During this time contractors reckon that each Saidi will do 120 c.m. at 12½ milliemes per cubic metre = £E.1.5 worth of work. Another peculiarity of the Saidi is that, in addition to his advance, he receives from the contractor, on each market day, 5 piasters (1s.) to spend at the market and get a little meat, &c., to help out his bread. This is an invariable custom. There are at least five market days during the 40 days' closure, so each Saidi receives a matter of 25 p.t. in addition to his advance. It is obvious, therefore, that at the end of the contract the Saidi is in the contractor's debt to the extent of about 75 p.t., which the contractor has no chance of recovering unless he has other work immediately following on the closure work.

To consider the contractor's other expenses in connection with the contract. The "Sawaq" is paid 1½ milliemes per cubic metre of work done by the men brought down by him. Some of this goes to his "sub-Sawaqs"—men who have brought twenty or thirty labourers from a small village. By this arrangement it is in the "Sawaq's" interest to get his men to work as much as possible. He is a very important person, for he is the only man that has any influence with the Saidis.

When the earth has been placed on the canal bank it has to be neatly dressed by special gangs of men who are, more or less, skilled labourers. Their rate of pay is uniformly 1 millieme per cubic metre of total excavation.

The contractor has to provide baskets (for carrying the earth), fases (hoes), and bell tents, in which the Saidis sleep and keep their bread. The cost of this works out usually at 2 milliemes per cubic metre, In addition, we have engineering, management, and travelling expenses—on a contract of about 250,000 c.m. this amounts for the closure work of 100,000 c.m. usually to about 2 milliemes per cubic metre.

The cost of laying the canal dry is included in the contractor's rate per cubic metre. It varies enormously, according to local conditions, and according to the number of canals over which the work is distributed. A cube of 100,000 c.m. clearance might be distributed over about six canals. The cost of making the banks and removing them and unwatering would not be less than £E.5 per canal—£E.30 in all.

Every time the contractor goes along this work he is assailed with clamours for "Bakhshish"—very often he must comply to keep his men in a good humour. The amount disbursed in this way, especially if the weather is bad, is not less than £E.20 on a 100,000 c.m. contract, but perhaps it would be better not to count it in the total cost.

We find, then, that the contractor who receives about 100,000 c.m. to do in a forty days' closure must reckon on each man he brings down doing about 120 c.m. during that time. Thus he must bring about 840 men on to the work. If he sends for 1050 and gets 840 to the work, he will be very lucky. To send for 1050 men he must put down £E.2100. His other expenses will be for baskets, &c., about £E.100, and train fares—say he needs a capital of £E.2500 to start with. If he is working with his own money, well and good; the £E.2500 otherwise employed at 9 per cent. would earn about £E.100 during five or six months they are tied up. Most contractors in Egypt work with borrowed money at iniquitous rates of interest—it is not uncommon to have to pay 10 per cent. of the amount of the final bill, *i.e.*, if this contractor gets his work at the rate of 30 milliemes per cubic metre from the Government, his final bill is about £E.3000, and he has to pay £E.300 to the man who provided him with a capital of £E.2500 at the start, five or six months before. We will assume, however, that the contractor is working with his own money. He pays out £E.2100 to a "Sawaq" to bring 1050 men, and 840 turn up. These men, at 120 c.m. per man, in the forty days do 100,800 c.m. He has to pay the "Sawaq" £E.151, and baskets, tents, &c., cost him £E.202. Management expenses, reckoned at 2 milliemes per cubic metre, amount to £E.202; we can now sum the total outlay on the part of the contractor:—

	£E.
Paid to "Sawaq" to bring men	2100
"Sawaq's" payment	151
Baskets, tents, &c.	202
Dressing banks	100
Management expenses	202
Payment to 840 Saidis on five markets days, 5 p.t. per man per day	210
Fares of 840 Saidis at 15 p.t. per man	126
Cost of unwatering	30
Interest on capital for closure period	70
Total	3191

Considering the hazardous nature of the work, the worry, anxiety, &c., it is fair to reckon that reasonable profit is 15 per cent. on the actual cost, or £E.478. The contractor's final bill for the above contract of 100,800 c.m. should therefore amount to £E.3669, or, roughly speaking, a rate of 36½ milliemes per cubic metre. The contractor has outstanding in the "Sawaq's" hands the advances for 210 men at £E.2 = £E.420, and the 840 Saidis each owe him about 75 p.t., or £E.630 in all. If he has work following immediately on the winter work, he can hope to get this £E.630 back, but the £E.420 in the "Sawaq's" hands should be written off. Assuming, then, the favourable case, his total outlay would be £E.2561 and his final bill £E.2561 + 15 per cent. = £E.3045, or about 30½ milliemes per cubic metre.

The contractor can make further economies in the following ways:—(1) By reducing expenditure on fares of the Saidis; (2) by cutting down management expenses. If the contract is awarded early enough, before the closure, he can bring the men down the river in sailing boats, and thus reduce the fares from 15 p.t. to 8 p.t. per man—an economy of £E.59. By dispensing with an engineer, he can save another ½ millieme per cubic metre, or, say, £E.50. By this means he can reduce his actual outlay on the work to £E.2453. But we have assumed that the contractor has other work in the same neighbourhood following immediately on the closure work. This work will be easier than the closure work, consisting, as it does, chiefly of bank repairs done in the dry. The heavy management expenses due to getting the Saidis down from their villages fall away to a large extent. The work being lighter and drier, the cost of baskets and hoes is less, and the men can do more in a day at a less rate.

For bank repair work each man can do about 5 c.m. per day at 10 milliemes per cubic metre, and thus earn 5 p.t. per day. The contractor must reckon on getting his whole work finished by about March 15th, as the men will then go back to their villages for the harvest. It now remains to find out how much work the men who have done the closure work can do before March 15th, and how much it costs. Assume the 40 days' closure ended on February 5th, a normal date. This leaves about 40 days before the men will go away, or 35 working days, allowing for market days. Each man will do 175 c.m. during this time at 10 milliemes per cubic metre = £E.1.75.

During this latter period on each market day the Saidi receives 15 p.t. instead of 5 p.t., for he has by now exhausted the supply of bread he brought with him from his village. So on the five market days he gets 75 p.t. He still owes the contractor 75 p.t. from the winter work, and as he has done 175 p.t. worth of work by about 15th March, he receives finally another 25 p.t. from the contractor, and they are then quits. The 840 men in 35 days will do 147,000 c.m. at 10 m/m per cubic metre = £E.1470.

The contractor's total outlay on the 147,000 c.m. is:—

	£E.
Cost of earthwork, 147,000 c.m. at 10 m/m per c m.	1470
"Sawaq's" payment, 1½ m/m per c.m.	220·5
Baskets, tents, &c., 1½ m/m per c.m.	220·5
Management expenses, 1 m/m per c.m.	147
Dressing banks, 1 m/m per c.m.	147
Interest on capital	30
Total	2235

For this he does 147,000 c.m.; therefore the cost per cubic metre is about 15½ m/m.

Assuming that the 100,800 c.m. of closure work and the above 147,000 c.m. form one contract, the contractor's total outlay will be £E.2561 + £E.2235 = £E.4796 for a cube of 247,800 c.m., or 19½ m/m per cubic metre, about. To get a fair 15 per cent. profit the rate should therefore be about 22½ m/m per cubic metre for a contract where 40 per cent. of the work is done during closure. If closure work is put up to tender separately it cannot be done for less than about 25 m/m per cubic metre cost price. The absolute cost price of a contract not preceded by closure work has not been worked out; other considerations come in, such as the question of letting the Saidis return home for harvesting and bringing them down again.

From the various considerations mentioned above, it seems that the essential, to obtain cheap work, is that the period allowed should be ample to allow the Saidi to work off his advance, and not only his own advance but also his share of the advance of the Saidis who did not eventually come and work. A normal average figure is that 20 per cent. of Saidis do not turn up—hence, if the advance is A p.t., each Saidi has to work off an amount equal to $\frac{5}{4}$ A p.t. Suppose a Saidi does b c.m. per day at a p.t./c.m., he takes $\frac{5}{4}$ A/a b working days to work it off. To this add one-sixth for market days and a constant of 10 days, to allow for unwatering canals, for measurement of work and for bad weather, then if N is the minimum time allowed for a contract, in days,

$$N = \frac{35\,A}{24\,a\,b} + 10$$

where A = advance in piastres per man.

a = rate at which Saidi works in p.t. per cubic metre.

b = No. of cubic metres per day done by the Saidi.

$a\,b$ is very nearly constant at 5 p.t. If the advance is 200 p.t., the minimum time over which a contract should last is 68 days—say 2⅓ months. We have the interesting deduction that, up to 1909, after a good flood a longer time should have been allowed for finishing a contract,

* 1000 milliemes (m/m) = 100 piastres (p.t.) = one pound Egyptian = £1 0s. 6d.

than after a bad one, for a good flood means good crops in the Saidi's home, and therefore a greater inducement is needed to make him come to Lower Egypt and work, *i.e.*, A gets bigger, and so N gets bigger. But the date at which the Saidi returns for his harvesting is more or less constant, hence, after a good flood, the closure should begin early. In 1909, however, the Esneh Barrage was completed, which has obviated the effects of a bad flood on the Upper Egypt basins. Hence one of the minor good effects of the construction of this barrage is a tendency to steady the earthwork rates in Lower Egypt.

The conclusions reached in the above note, and the conditions on which they are based, can now be summarised:—

(1) The "Sawaq" brings down 80 per cent. of the men for whom he has received advances.

(2) The contractor has other work following immediately on the winter work.

(3) The Saidi is content to earn 5 p.t. per day, and moves about 4 c.m. of earth per day during closure and 5 c.m. afterwards.

(4) The contractor works with his own money.

(5) The closure begins early enough to enable the Saidis to work off their total advance before they return to their homes about the middle of March for the harvesting. This period is determined by the formula,

$$N = \frac{35}{24}\ \frac{A}{a\,b} + 10.$$

(6) The closure work must be about 40 per cent. of the total work during and after closure.

(7) Under these conditions a rate of 22½ m/m per cubic metre gives a profit of about 15 per cent. on the total outlay.

In the above discussion no allowance is made for the fact that the contractor often takes it out of the Saidi to an amount of about 10 per cent. of the cube he has done. In earlier years, too, the Government did not entirely escape his wiles. With improved organisation and methods of measuring and checking, this has now been considerably reduced, though by no means entirely eliminated.

STERILISATION OF WATER SUPPLIES BY ULTRA-VIOLET RAYS.

IT is nearly fifty years since Clerk Maxwell enunciated his classical theory that light is an electro-magnetic disturbance in the form of waves propagated through an electro-magnetic field. Since then our knowledge on the subject of radiant energy has been greatly augmented by Hertz, Crookes, Röntgen, Becquerel and others, and some of their discoveries are already being extensively applied. The investigation of electric waves by Hertz in 1888 laid the foundations of wireless telegraphy, and the work of Crookes and Röntgen resulted in the utilisation of X-rays in medical science. Considerable attention is now being devoted in France to the utilisation of ultra-violet rays, particularly for sterilisation purposes, and it is the purpose of this article briefly to review the earlier research and results so far achieved.

Sir Isaac Newton showed that ordinary white light was composed of light rays of different colours ranging from red and yellow through green to blue and violet, and it was found later that practically all sources of light also emit rays which are not visible. If a beam of light be passed through a prism there are, in addition to the visible rays which constitute the spectrum, other invisible rays continuing the band at the red and violet ends, known respectively as the "infra-red" and "ultra-violet rays." The former are distinguished by their heating effect, whilst the latter are characterised by their chemical activity, and for this reason are sometimes known as "actinic rays." It has long been recognised that sunlight is capable of influencing chemical reactions; for instance, a mixture of hydrogen and chlorine is stable in the dark, but instantaneously combines with an explosion when exposed to sunlight, and many synthetic colours when exposed to sunlight are rapidly bleached. Most of these effects are now attributed to the presence among the visible rays emitted by the sun of invisible ultra-violet rays.

The ultra-violet rays differ in their physical properties from ordinary light waves in several respects. The wave-length of the rays constituting visible light, range from 32 millionths of an inch for the extreme red to 15 millionths of an inch for the extreme violet, whilst the ultra-violet rays are of still shorter wave-length. Different materials are transparent to ultra-violet rays in different degrees, and ordinary glass, for instance, though transparent to visible light rays, is practically opaque to ultra-violet rays. Quartz, on the other hand, transmits the rays down to a wave length of 8 millionths of an inch, whilst fluor-spar is slightly more transparent. The fact that ultra-violet rays can be registered on a photographic plate has long been known, and the rays can be transformed; that is to say, changed into visible rays of longer wave length, by certain fluorescent materials such as barium platino cyanide. One of the best methods of demonstrating the presence of ultra-violet rays in the invisible region beyond the violet end of the spectrum is to cause the rays to fall on a screen covered with this material when a pronounced fluorescent effect is obtained.

The Kathode and Röntgen rays had not been long discovered before numerous attempts were made to apply them in the arts. Hogarth, a miller of Fifeshire, proposed in 1896 to improve the properties of flour and other food stuffs by submitting the same to the rays emitted by incandescent electric lamps, high tension electric sparks, and other forms of radiant energy. He also proposed to improve the keeping qualities of fermented liquors by similar means, and patented various forms of apparatus for giving effect to such methods of treatment. From his published work, however, it appears that he did not clearly distinguish the difference between the various types of radiant energy suggested, and as he advocated the employment of the ordinary electric incandescent lamps with glass bulbs, most of the ultra-violet rays emitted by the glowing filament—an ordinary carbon filament gives out only few waves of short wave-lengths—were absorbed by the glass, and, therefore, were not available for acting on the liquid treated.

Preisz, a chemist of Copenhagen, came nearer to the solution of the problem when he suggested the employment of the arc light, which is known to be rich in ultra-violet rays. He appreciated the fact that different liquids are permeable to the rays to a variable extent, and that, in order efficiently to sterilise some liquids, it is necessary to cause them to pass the source of light in the form of a thin film. This investigator devised a sterilising apparatus comprising a rotatable drum adapted to surround the carbon points of the arc, through which drum the liquid was passed. The rotation of the drum caused the liquid to assume a thin film on the wall of the vessel, so that the absorption of the rays by the liquid was compensated for. One objection to this apparatus, as originally described by Preisz, is the difficulty of preventing contamination of the liquid by the fumes given off by the arc; so that the scheme does not appear to have attracted much attention as a practical method of sterilising potable liquids.

Seiffert, a University lecturer of Leipsic, appreciated the necessity, when treating liquids with rays of short wave length, of employing material through which the rays will pass, and the apparatus described by him in 1905 was provided with windows of quartz, fluor-spar, or rock crystal, materials which are permeable to ultra-violet rays. The source of energy suggested in this case was high-tension electric sparks, but although the arrangement showed many ingenious features, the amount of ultra-violet rays emitted by electric sparks is too small to carry out sterilisation treatment on a large scale.

The bactericidal properties of ultra-violet rays are believed to be directly attributable to the rays themselves, and not to the intermediate formation of ozone. Sterilisation of water supplies on a large scale by means of ozonised air has, of course, been carried out for several years. In 1903 Messrs. Siemens and Halske erected an installation at Paderborn, in Germany, which treats the water supply of the town at the rate of 25,000 gallons per hour. The ozone is produced by the silent electrical discharge between two concentric cylinders, and the air containing ozone is led up towers filled with stone and gravel, through which the water trickles. In the Vosmaer ozonising plant, which is in use at Philadelphia, ozone is produced by a brush discharge between pointed combs and a flat electrode, and is brought into contact with a counter current of water beneath a perforated plate. The cost of this process is said to be very small, amounting to a little over two dollars per million gallons of water treated. Other systems of sterilising water supplies by means of ozone are in operation in Holland and France. The ozone does not appear to alter the taste of the water, as after a short time it decomposes into oxygen, and a little of this gas in solution is a desirable constituent. Sterilisation by means of ozone seems to be due to a direct poisoning of the bacteria in a manner similar to the germicidal action of formaldehyde, salicylic acid, and other chemical preservatives, but the bactericidal properties of ultra-violet rays are due to the specific action of the rays themselves, though the reason for this action has still to be elucidated.

It has been known for a long time that the mercury vapour lamp when operated emits ultra-violet in addition to blue and green rays, and Cooper Hewitt, to whom its development is chiefly due, and other investigators have attempted to incorporate with the mercury materials which are capable of adding red rays, in order to give a more pleasing effect to objects illuminated by the light. The result of recent work with this type of lamp goes to show that what was an undesirable element for illumination purposes is likely to be of immense service in preventing the propagation and dissemination of disease germs. The experiments carried out by Shenstone at Clifton College, and Hutton at Manchester, some years ago, on the fusion of quartz, led the way for Heraeus and Küch to construct mercury-vapour lamps of this material, and such lamps are now being manufactured by a number of firms, not only for illumination purposes, but also for sterilising liquids. England shares in the new development, for Johnson, Matthey and Co., Limited, and the Thermal Syndicate, of Newcastle-on Tyne, are makers of fused quartz, and the Brush and Westinghouse Companies have placed quartz-mercury lamps on the market for illumination purposes. It is, however, in France that attention has first been given to the sterilisation of water supplies on a large scale by means of ultra-violet rays.

On January 7th, 1907, M. Armand Billon Daguerre deposited a sealed note in the archives of the Académie des Sciences which was opened on March 1st, 1909, soon after Courmont and Nogier had read a paper before the Académie, relating to some discoveries they had made on the bactericidal effect of the rays emitted by quartz-mercury lamps. Billon-Daguerre had killed the bacillus staphylococcus pyogene aureus by five or six seconds' exposure to an arc lamp provided with electrodes of special composition, and had obtained good results in the sterilisation of milk by causing it to flow in a film over an inclined plate whilst exposed to the arc.*

Courmont and Nogier"s experiments were conducted with a Kromayer lamp, a type of quartz-mercury lamp which has been developed for therapeutical purposes, and they found that by using a strong current they were able to kill the bacillus coli in clear water in one or two minutes' exposure. The lamps could be operated either immersed in the water or supported above the surface.† The results obtained by Courmont and Nogier seemed to be of sufficient importance to justify applying for patent protection, and the latter investigator appears to be the first to claim definitely the use of quartz-mercury lamps for sterilising liquids.

Most of the work so far carried out has been in connection with the treatment of water, but efforts are also being made to sterilise milk by the same means.

The Westinghouse Cooper-Hewitt Company has for some years constructed mercury vapour lamps of the type developed by Cooper-Hewitt and others for illumination purposes, and, appreciating the importance of the quartz-mercury lamp, foresaw in connection with sterilisation work possibilities of a considerable extension of its original business. A large amount of experimental work has been carried out by Professor Victor Henri, of the Sorbonne, Dr. André Helbronner, and Dr. von Recklinghausen, within the last two years for the purpose of developing a practical scheme of water sterilisation on a large scale.

One of the earliest types of sterilising apparatus embodying the results of these experiments was placed upon the market for hospital use about twelve months ago. It consists of a cylindrical tank divided by means of inclined baffle plates into a number of compartments, through which the water to be sterilised is caused to flow with a spiral motion. The quartz-mercury lamp is placed in the upper part of the tank on a pivotally arranged support, so that it can be tilted for starting. By means of this apparatus, which is comparatively small and simple in construction, it is stated that 132 gallons of sterilised water per hour can be produced by means of a single lamp taking 3 ampères at 110 volts. The water is taken direct from the mains, and its rate of passage through the steriliser is regulated by a valve in the inlet pipe, so that it does not exceed the maximum capacity of the apparatus. By means of an apparatus of this character a plentiful supply of absolutely sterile water can be obtained in a short space of time, and, moreover, the water retains all its salts and gases in solution, and is unaffected as regards taste.

For sterilising town water supplies on a large scale the water is led through conduits of zig-zag form and the quartz-mercury lamps are supported above the surface of the water on float mechanism in order to allow for alterations in the level of the liquid. Since the ultra-violet rays are absorbed to a greater extent by air than by water, it is that important the lamps should be as close as possible to the surface, and better results are said to be obtained when the formation of ripples on the water is avoided.

One of the most remarkable results of these researches is the discovery that pathogenic bacteria as a class are more susceptible to the influence of ultra-violet rays than other bacilli known to be harmless. For instance, in a certain experiment it was found necessary to expose a sample of water to the rays for a period of 120 seconds in order to destroy all the bacteria, though the pathogenic bacteria had all been killed after 20 seconds' exposure. The number of bacilli present in the water per cubic centimetre does not appear to matter, so powerfully germicidal are the rays.

There does not appear to be any analogy between the action of heat and ultra-violet rays on different species of microbes. The bacillus of anthrax, for instance, which is capable of resisting the effect of a temperature of 120-140 deg. Cent. for some time very quickly succumbs to the action of ultra-violet rays, an exposure of about thirty seconds being usually amply sufficient, and bacillus coli, which is extremely sensitive to heat, is destroyed in about the same period of time.‡ It is claimed that with the conduit apparatus, with lamps supported above the surface of the water, it is possible to destroy all the pathogenic bacteria with an expenditure of electrical energy sufficient to operate two quartz-mercury lamps consuming 3.5 ampères at 220 volts.

It is proposed to make use of the selective action of ultra-violet rays for the purpose of preparing pure cultures of yeast, for it has been found that undesirable microbes which affect the quality of yeast are killed on exposure to the rays, whereas the yeast cells are very little affected, if at all, by a short exposure to a quartz-mercury lamp. There is also a possibility of superseding the methods adopted at present for sterilising fermented liquors intended for export to tropical countries. In Germany, for instance, large quantities of Lager beer are sterilised by heat, which does not, as a rule, improve the quality of the liquor as regards taste. It is believed that beer can be sterilised in the cold by exposure to quartz-mercury lamps in some of the forms of apparatus now being constructed.

In the sterilising apparatus developed by Nogier, a quartz-mercury lamp is immersed in the water to be sterilised, and the water is allowed to flow through the tank at a rate which is controlled by an electro-magnetic device connected in the lamp circuit. The tank is divided by a partition into two parts, and the water flows through an orifice in the partition surrounding that part of the lamp where most of the rays are developed. There is therefore little chance of infected water passing through the apparatus without being sterilised. The terminals of the lamp are brought outside the tank, and the latter is mounted on a transverse shaft, so that it can be bodily rocked in order to start the lamp in operation when the circuit is closed. The tank is cylindrical in shape, arranged with its axis horizontal, and provided with hinges in order to facilitate access to the lamp.

An important feature in connection with any system of sterilising water by means of ultra-violet rays is to prevent the microbes from being sheltered from the rays by solid particles in the water. Solid matter can of course be separated by filtration, though even the best filter beds fail to remove the germs entirely. Where it is impracticable to filter the water before exposing it to the action of the quartz-mercury lamp, it is necessary to provide means for turning over the solid particles of dust in order to expose them on all sides to the rays. This can be done by agitating devices or by causing the current of water to change its direction of flow whilst in the sphere of

* "Comptes Rendus," 1909, page 542.
† "Comptes Rendus," 1909, page 523.
‡ "Comptes Rendus," 1910, page 52.

action of the lamp, so that the microbes have little chance of hiding themselves on the remote side of a solid particle in the water.

It would appear that the usefulness of the quartz-mercury lamp is by no means limited to sterilisation. It is already well known as a powerful and economical illuminant, but there is a large field for investigation of its action in connection with chemical reactions. Many years ago Tyndall showed in an interesting lecture experiment that sunlight promoted the combination of sulphur dioxide and oxygen to form sulphuric anhydride, and attention has already been drawn to the quartz-mercury lamp as a means for carrying out this reaction. Large quantities of sulphuric anhydride are now manufactured by the contact process, and it would be an interesting development to find the expensive platinum contact substance replaced by ultra-violet radiation.

This and other applications of ultra-violet rays should form a profitable field of inquiry for research chemists, and the results already achieved by physicists and bacteriologists have to some extent prepared the ground for further investigators.

UNEMPLOYMENT INSURANCE.—We are asked to state that a conference will be held at Toynbee Hall, in Whitechapel, on Monday evening, 19th June, at 8.15, in order to discuss the unemployment insurance proposals. This portion of the National Insurance Bill at present chiefly concerns every employer and workman in the building and engineering trades, and it is hoped that all organisations in East London in these trades, whether of employers or workmen, will send representatives.

THE TURIN EXHIBITION.

(By a Special Correspondent in Italy.)

No. IV.*—THE CENTRAL POWER STATION. MACHINERY AND ELECTRIC HALLS.

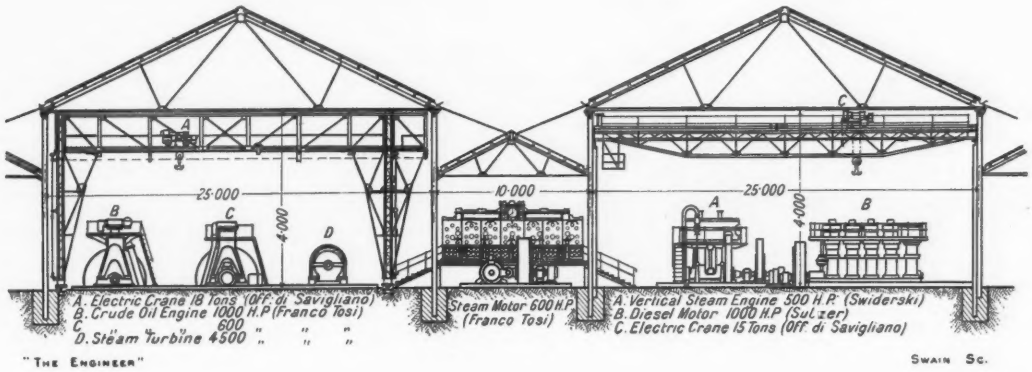
THE Central Station, which gives light and motive power to the whole Exhibition, with the exception of the British and Swiss sections, occupies the upper part of the great Machinery Hall, and is separated by an arch with a fire-proof screen from the staircase which leads down to the English domains.

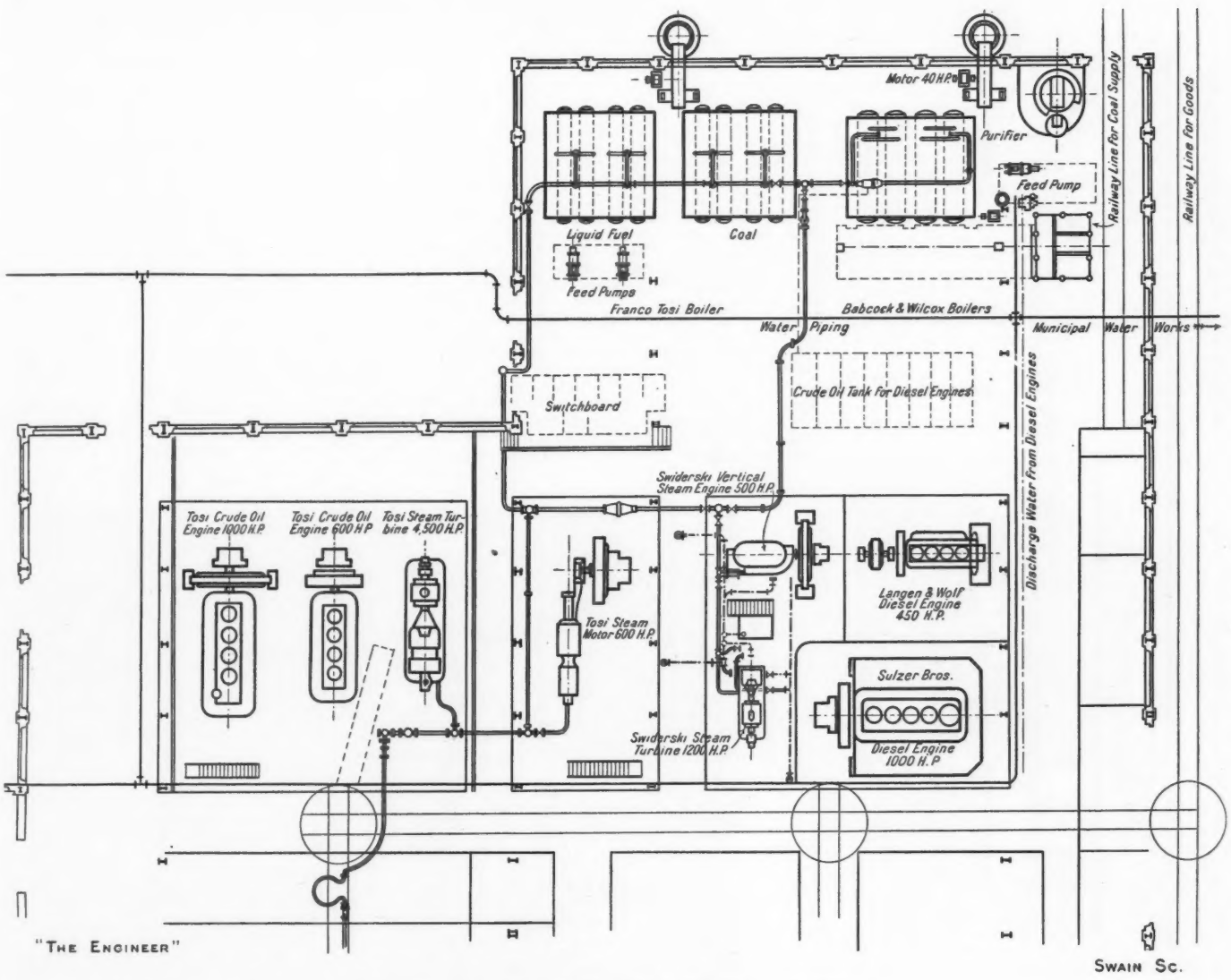
It is undoubtedly one of the most interesting exhibits here, for the heart which gives life to the Valentino Park is throbbing before the eyes of the observer. This publicity is intentional. The Committee might have made use of the municipal power station, but have preferred to be independent for the purpose of affording an exhibit of work and a study for the general public. The engineers, too, connected with the section have the advantage of a constant exchange of ideas with their brethren of other countries, for the firms chosen for the production of energy in the central station are not only, as they well might have been, national ones.

The boilers which supply the various steam engines are placed at the extreme end of the gallery—see plan—and are in three groups. Of these the two with four units on the right-hand side are by Babcock and Wilcox. They have a heating surface of 6182 square feet each, and evaporate normally about 8.5 lb. of coal per square foot of steam at 190 lb. working pressure, and are fitted with steam superheater and automatic chain grate and stoker, the coal being broken up by a coal breaker coupled up to a little steam motor. The draught for the boilers is effected on the Louis Prat system, worked by two electric motors of 40 H.P., and the feed water, which passes through a Rosetti purifier, is fed to the boilers by two Worthington pumps, of which one is steam and one electric.

The other group on the left is by the equally well-known firm of Franco Tosi, of Legnano, which, indeed, exhibits a complete power station in this section. It consists of two batteries of two water-tube units each, with superheater, with a total heating surface of 1812 square metres and a working pressure of 16 atmospheres reduced, however, to the Committee's standard of 13 atmospheres. Of these two batteries, the one on the extreme left burns liquid fuel, and the other coal, with mechanical draught and underfeed stoker, of which details and section are exhibited by the manufacturing firm in the English machinery hall. The feed is automatic, and the exhaust from the two duplex pumps enters the feed-water heater. In the intervening space between the boilers and the engines are the water tanks and the crude oil tanks for the Diesel motors, the cooling water from which goes to the boiler feed tank. The steam piping, made in part by Franco Tosi and in part by Hockdruck-Rohrleitungen, of Berlin, is fitted with sectional valves, so that any of the following engines may be worked with one or all of the different boilers:—(1) The Tosi steam turbine (4500-5000 horse-power, 1500 revolutions), direct coupled

* No. III. appeared June 2nd.





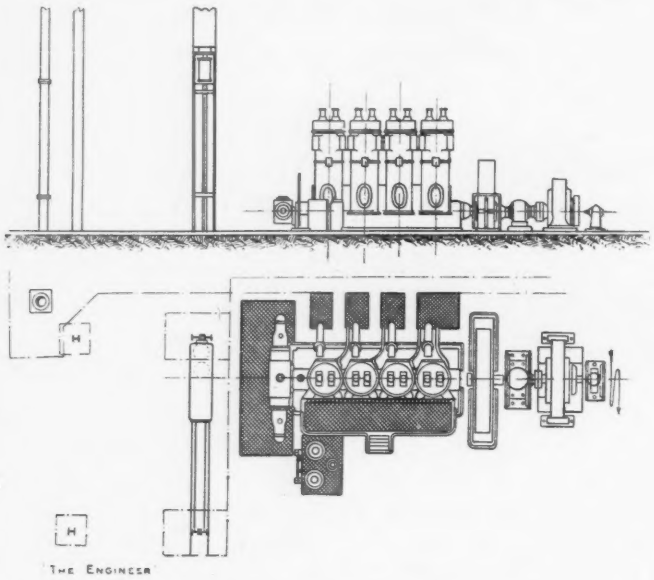
TURIN EXHIBITION—POWER STATION IN THE MACHINERY HALL

up to a 5000 horse-power alternator by the Società Italiana Ganz di Elettricità of Milan. (2) The compound tandem engine also by Franco Tosi (600-800 horse-power, 125 revolutions) direct coupled to a 600-800 horse-power alternator, fly-wheel type, with separate exciter by the Officine di Savigliano, of Turin. (3) The steam turbine by Swiderski, of Leipsic (1200 horse-power) coupled up to a 1200 horse-power alternator by Brown, Boveri, of Baden; and (4) the vertical steam engine by the same firm (500 horse-power, 150 revolutions) coupled up to a 500 horse-power alternator with internal rotary inductor by the Officine di Savigliano, of Turin. The oil motors are as follows:—Two by Franco Tosi, of Legnano, for crude oil, one of which (600 horse-power, 150 revolutions, four-stroke cycle) is working now, and the other (1200 horse-power, 150 revolutions, two-stroke cycle) will be erected a little later on. These are, or will be, coupled up to two alternating-current dynamos, with three-phase current (6400 volts, 50 cycles, 150 revolutions) by the Tecnomasio Italiano, of Milan. One Diesel motor by Sulzer Brothers, of Winterthur (two-stroke cycle, 1000 horse-power, 150 revolutions), coupled up to an alternator, fly-wheel type, with separate exciter by the Officine di Savigliano, of Turin.

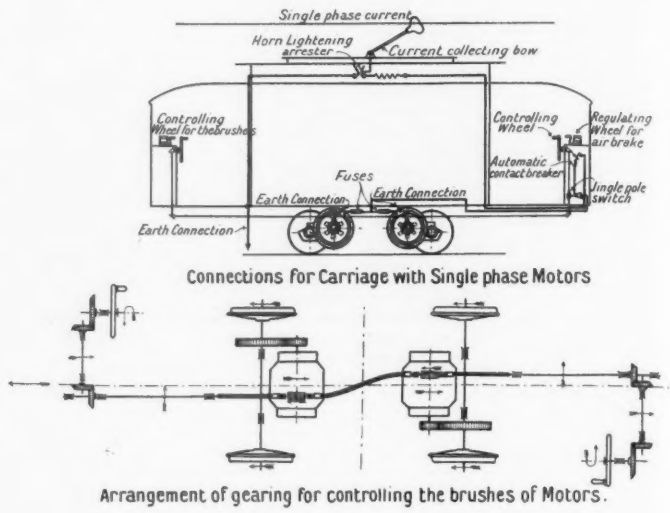
The above seven units communicate with the central storage section, which can also be connected in case of necessity with the Turin Corporation electric station, and which, divided into seven sections, gives the current to the four principal lines which supply the four quarters of the Exhibition.

The Diesel engine on the extreme right of the line behind the Sulzer engine is by Langen and Wolf, of Milan, the original introducers of the suction gas motors, and is a four-cylinder motor of 450-550 horse-power at 250 revolutions, and with a 8500 kilo. fly-wheel of 2700 mm. diameter. It is coupled up to a continuous-current dynamo made by the Società Italiana Ganz di Elettricità, of Milan; but this engine and dynamo are independent of the rest of the plant. The motive power thus generated in the hall will be seen to be more than 10,000 horse-power.

The 450 horse-power Diesel engine—see sketch—last mentioned is worthy of remark because of the extreme ease of getting at the moving parts between the uprights or through openings covered by splash guards. The base, cast in one piece, has the four cylinders and the horizontal compressor fitted to it. The liners, made of hard cast iron, are fastened only at the upper end to the cylinder bodies, the joint for the water jacket being packed with india-rubber. The four cylinders, lubricated by a quadruple piston pump, have each of them its own fuel pump controlled by a centrifugal governor. The cylinders have four valves for starting, feed, air admission, and exhaust, and are 440 mm. in diameter with a 480 mm. stroke. Two circulating oil pumps lubricate the crank shaft, and the waste oil is all drawn off by a suction pump and filtered. Compressed air is used for starting.



DIESEL ENGINE BY LANGEN AND WOLFF

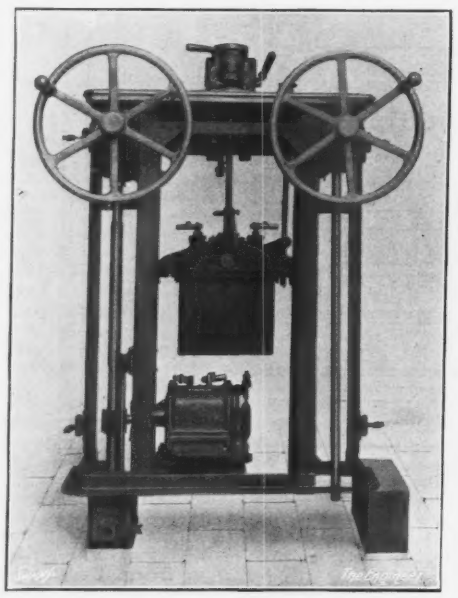


Connections for Carriage with Single phase Motors

Arrangement of gearing for controlling the brushes of Motors.

MONOPHASE CAR FOR PARMA TRAMWAYS

The above type of engine is undoubtedly destined to become even more popular here now that the reduction of the duty on petroleum has rendered the use of crude oil economically possible. The firm of Langen and Wolf alone has, in fact, already put on the market motors of this sort for more than 12,000 horse-power, and four are now in construction for the Taranto Arsenal. The makers' former type of engine, suction gas, of proved economy—for they consume only about 300-350 grammes of English anthracite per horse-power for hour—has now been sold by them here to the extent of about 130,000 horse-power, and an example is to be seen in the Hall of Electricity in the shape of a 350 horse-power two twin-cylinder suction gas motor making 160 revolutions, belted up to the Officine di Savigliano's continuous current dynamo —225-260 kilowatts, 500 volts, 500 revolutions.



CONTROLLER FOR MONOPHASE CAR

FRAMEWORK FOR HIGH TENSION SWITCHBOARD BY THE TECHNOMASIO ITALIANO

But Messrs. Langen and Wolf, which, in spite of its foreign name, is an Italian firm working with an Italian staff, is not alone in showing the high standard which home engineers have touched. The firm of Franco Tosi, of Legnano, one of the first pioneers in Italy of this branch of science, is a household word. Of the Officine di Savigliano, of Turin, also it may be said, standing in the Exhibition:—"If you look for their monument gaze around." Too much space would be occupied by a list of their exhibits, the most important of which may well pass unobserved as being an integral part of the Exhibition itself. Such are, for instance, the 1000 horse-power, the 600 horse-power, and the 500 horse-power alternators, and the 225 horse-power continuous-current dynamos already mentioned. In the same category may be included the 18-ton continuous-current crane for Tosi's section, and the 15-ton three-phase current one in the centre part of the gallery, besides many other minor details of the general plant. Their stand in the Hall of Electricity comprises, among other exhibits, a quantity of electric pumps, ventilators and continuous-current dynamos, samples of chains with breaking loads from 3 to 90 tons, three-phase transformers with oil cooling and tensions up to 60,000 volts, a tram-truck with two motors of 35 horse-power each, and a 400 horse-power suction gas engine of 160 revolutions working for the committee.

Another of the great home firms worthily represented at the Exhibition is the Tecnomasio Italiano, of Milan. This house, originally of foreign extraction, being derived from an offshoot of Brown-Boveri, of Baden, has long found favourable soil here, and, having naturalised itself, has, with its Italian staff and workmen, proceeded on the upward course that has now landed it in the first line among the electrical specialists of Italy. From a production of 500 tons in 1904, it rose by annual steps to 1700 tons at the beginning of 1908, when it assumed its present name as representing the union of the old firms of the Unione Elettrotecnica Italiana with Gadda and Co. The fusion has been successful, as is proved by its present output of 3500 tons, and by the fact that the old works have had to be changed for the new ones, just built, and capable of holding the 3000 workmen of whom the business has need. The exhibit comprehends in a limited space the firm's principal specialities. In addition to the two alternating current dynamos of 1000 and 720 horse-power already mentioned, it has in the Central Hall a centrifugal pump for the water supply driven by a three-phase motor (175 horse-power, 1000 revolutions, 500 volts, 50 cycles).

In the Hall of Electricity it shows some of the plant just made for the Cairasca and Pescara installations; a three-phase alternator (3500 horse-power, 504 revolutions, 3500 volts, 42 cycles), and three single-pole switches, 100,000 volts. These items are characteristic

of the standard business of the Tecnomasio Italiano, which numbers among its clients most of the great power stations of Italy, together with the Edison Company and the State railways, and which has in the last years made generators of 1000 horse-power upwards to the extent of over 235,000 horse-power, and transformers on the same scale, to say nothing of dynamos and motors. Among the last orders executed may be quoted that of the Grosotto power station for three generators, 12,000 horse-power, 315 revolutions each, and three groups of three transformers, 2850 kilo-volt-ampère each, 75,000 volts; for the Bardonecchia installation, three generators, 2500 horse-power each, 500 revolutions, three three-phase transformers, 2200 kilo volt ampère each, 48,500 volts, and three tri-phase motors, 2500 horse-power, 500 revolutions; and, for Papigno, two generators of 9000 horse-power each, with 900 revolutions; while among the as yet unfinished power stations, Pescara and the giant Adamello may be mentioned among their clients, the former for four generators, 8500 horse-power each, 420 revolutions, and three groups of three transformers, 3600 kilo-volt-ampère each, 90,000 volts, and the latter for five generators 6500 horse-power each, 420 revolutions, and seven three-phase transformers of 2250-1500 kilo-volt-ampère each and 60,000 volts.

Another interesting exhibit shown by this firm consists in one of the trucks—see illustration—of the motor carriages for the Parma tramways, of which it has just constructed thirty. This installation represents the first application for the purpose of the mono-phase system in Italy, each carriage having two Deri mono-phase motors of an average of 25 horse power, 400 volts, 20 cycles. The advantages claimed are those of high total efficiency at large ranges of speed and load, and maximum simplicity in the carriage equipment, which, in fact, seems more of a mechanical than an electrical one, inasmuch as the controllers, resistances, and transformers can be dispensed with. For manœuvring the carriage a system of small shafts placed alongside are fitted with bevel wheels to regulate the motor brushes, and are coupled at each end of the carriage, where the controllers are generally placed, by bevel wheels to a vertical shaft which is fitted with a hand wheel. The electrical apparatus is reduced to a horn lightning arrester at the end of the carriage, a main single pole switch and two fuses for the motors. The main switch is driven by the vertical shaft above named through a sleeve running on the same and fitted with square threads, and there are special arrangements adopted to avoid damage to the motor in the case of the brakes being put on too suddenly. This science of electrical traction has in the last few years been very much developed by the Tecnomasio Italiano, particularly as applied to mining locomotives; and another branch to which the firm devotes especial attention is that of the high-tension switchboards—see illustration—which, in their latest installations, are constructed with open iron framing, as being stronger, easier to erect, and dispensing with the armoured concrete cells. As a proof of their prowess in the field of small engines also, a collection of little motors for spinning mills is being exhibited, while in a special stand is to be seen a Humphrey gas pump, for the building of which in Italy they have the monopoly.

I have dwelt at length on the part played in the Exhibition by the Tecnomasio Italiano, as it is one of those firms which has made the name of Italian electrical engineers famous in Europe.

Of the numerous other home exhibitors in the great Machinery Hall, the most celebrated names are those of Riva and Co., of Milan, the makers of turbines, and the Costruzioni Meccaniche di Saronno, but the former have confined themselves to a limited sample of their massive constructions, and the latter have their chief exhibit in the Locomotive Hall—see THE ENGINEER, May 19th. Among the rest may be mentioned Calzoni, of Bologna, with turbines, a show of good work by the Società Veneta per Costruzioni Meccaniche, of Turin, ventilators and dynamos; machine tools by the Società Manfredi, of Mondovì; some excellent lathes by the Officine Meccaniche Michele Ansaldi; and a very good stand of machine tools by the Società Anonima Dubosc, of Turin, including its patent milling machine with 14 spindle speeds and 14 feeds. The show of home-made machine tools is, on the whole, a promising one, for the country in this department is as yet dependent on other nations. Sweets, chocolate, bread, and cotton have each their special machinery in motion; a complete hygienic steam laundry is shown by Ing. Gerra, of Milan, and the Westinghouse brake system is practically demonstrated by the Compagnia Italiana Westinghouse, of Turin.

Fronting the bottom end of the great Machinery Hall, and on the other side of the statue to Prince Amadeus, is the entrance to the Hall of Electricity, containing also the Swiss section. Leaving this latter apart for the moment, the rest of the gallery is cosmopolitan, and gives somewhat the effect of a tidy lumber room. Among home exhibitors Craveri, of Turin, and Osculati e Carini, of Milan, have a telegraphic stand and a show of insulators with some interesting models. With these exceptions, and with those of the Tecnomasio Italiano and Officine di Savigliano already described, there is little of striking interest after having noticed Ing. Tedeschi, of Turin, rival of Pirelli of Milan, who exhibits submarine cables tested up to 120,000 volts. Belgium has a model of the Samaia block and signalling system, France an "overflow show," including motor fire engines and machine tools, and Germany a large stand in which Julius Pintsch, of Berlin, has a good exhibit of lighthouse accessories, whilst near it are shown alternators by Ganz with a segment, some tramcars, and an electric railway locomotive that seems exiled from its proper section.

The Swiss section, which, though mentioned last, is in reality the first seen on entering the gallery, is one of the most interesting in the whole Exhibition. Punctual in opening, independent for power and lighting, and with all its machinery in constant motion, small but self-sufficing, practical and complete, it shows organisation, commercial activity, and technical schooling of the highest standard, and seems a reflection of the nation itself. The machinery industry is naturally chosen as the principal exhibit, for, of Switzerland's population of 3½ millions, about 121,000, or 1 in 28, are engaged in workshops.

Turning and drilling, spinning and weaving, brick-making, concrete mixing, and river bed dredging; wood-working, printing, winnowing and grinding are to be seen performed by machinery. Power and delicacy are equally represented. From the Diesel engine to the chocolate papering machine, from the strength of the great steam turbine to the minute precision of the automatic watch-makers, all are fulfilling their separate task methodically and exactly, while above the palpitating hum of industry hangs in mid-air a colossal electric watch, which silently warns its countrymen against any relaxation of their efforts.

SOME FURTHER NOTES ON TRAIN RESISTANCE.

By C. F. DENDY MARSHALL, B.A.

ON July 24th of last year a test run with the engine George the Fifth took place between Crewe and Euston and back, the dynamometer records of which were published in THE ENGINEER for October 7th, on page 394.

On a former occasion, when Mr. Bowen Cooke gave some records in his book, "Developments in Locomotive Practice," I made a careful analysis of them, which appeared in THE ENGINEER of October 2nd, 1903. I have now subjected the new ones to a similar examination. These differ in one very important respect from the others, owing to the fact that the engine was being driven hard, and both speed and pull were continually varying, so that there is hardly a point which is free from the condition of acceleration, or the reverse. Mr. Cooke has kindly lent me large copies of the diagrams, so that I have been able to go more closely into the matter than would have been possible with the reduced copies given in THE ENGINEER. For the benefit of those readers who have not the original article at hand for reference, I give the following figures again:—

Diameter of driving wheels		6ft. 9in.	
Cylinders		20in. by 26in.	
		T.	c. q.
Weight of engine in working order...		59	15 0
,, tender ,, ,, ...		37	0 0
Total		96	15 0
Weight of train		357	9 3
Total		454	4 3

I have constructed a table, taking sixty-one cases, being nearly all the points at which the engine was indicated. As it would take up so much space if published in its entirety, I have picked out the more interesting cases, and append them below, retaining the numbers in the original table. It should be noted that diagrams were only taken on the level or uphill, never downhill.

I have put a plus or minus sign in the speed column to show acceleration or the reverse whenever the indications are clear, but it is not always possible. What is really required in these records in order to arrive at the true resistance of a train at different speeds is an instrument which records the acceleration on the roll of paper, and I am going to describe one presently which I have devised, in the hope that it may be of value in throwing further light on this fascinating problem. Without something of the kind, all records are necessarily more or less vitiated by the fact of a certain amount of acceleration existing, the value of which is not exactly known. At 50 miles an hour the taking of a diagram only occupies 1¾ seconds, so it is possible that sometimes the line of speed at that instant was even opposite to its general trend at the time. As a matter of fact, a continuous speed record would be a valuable addition to a dynamometer van, but it would not be so necessary if my "accelerograph" were fitted. It is worth noting also that, owing to settlement or relaying, the gradient at any particular point may differ materially from the general slope given by the boards. This is a matter which can also be tested by the instrument proposed.

The logarithm of the ninth column is obtained by multiplying the fourth and sixth together and adding .7762167 to the log. of the product. This column may be arrived at approximately by multiplying the product of the fourth and sixth by 6, the result being about ¼ per cent. too high.

In calculating the eleventh column, I have taken the weight of the engine and its tender at its full value, as is usually done. It must not be forgotten, however, that the weight varies as the coal and water are used up. The tender holds 7 tons of coal and 3000 gallons, or 13.8 tons of water. If this is supposed never to fall below 6 tons, the weight of the engine varies between 96.75 and 82 tons, the mean being 89.4, which is practically one-quarter the weight of the carriages. I have adopted this convenient relation in calculating column 13. The last three columns are all corrected for gradient, giving the corresponding figures for the resistance on the level. This is done by deducting 2240 divided by the third column, which is the component of the weight acting parallel to the rails in pounds per ton, being, of course, the same for both engine and carriages. It has been suggested that the full allowance ought not to be made going uphill, but I have thought it best to deduct the whole.

The cases numbered below 37 are taken from the journey from Euston to Crewe, which occupied 157¼ minutes for the 158 miles. From 37 on are details of the up journey.

In case 1, which I have taken at 5½ miles from Euston, neglecting the first three points where they indicated the engine, the acceleration must have been much greater than one would imagine from the diagram.

The highest engine resistance for this journey is in case 5, and on referring to the diagram, I find the explanation. She was over the Bushey trough, and no doubt taking in water. In the 1902 diagrams there is a notch in the line of pull when they took in water, owing to the temporary retardation, but it does not appear here. The pull must surely have fallen, so I rather suspect it has been omitted by the draughtsman in the course of smoothing out the vibrations which appear on the original record. The old dynamometer used by Mr. Webb registered thrust as well as pull, in which respect the new one is not an improvement.

Why the engine resistance is so low in case 6 I am unable to guess. It would have been a very interesting and valuable addition to the diagrams if the position of the reversing gear had accompanied the other records. I fancy the engine resistance is considerably higher when notched up. In case 12 we have an unexpected drop of over 100 horse-power, which all comes off the engine. This is just before they came to a trough, but whether that fact has any bearing on the figures or not I am unable to say. Case 20 gives the highest indicated horse-power, 1229.25.

In cases 37 to 39, the beginning of the up journey, there is enormous acceleration, the engine pulling magnificently all the way up out of Crewe. There is, of course, some mistake about case 37, where the M.E.P. works out above the working pressure of the boiler. It is evidently the speed which is wrong. In case 40 the speed seems to have been quite steady; she just maintained the 38 miles per hour on the 1 in 177. The total resistance, corrected for gradients, is 7.9 lb. per ton. Taking the length over the carriages as 770ft., Mr. Aspinall's formula gives 8.45 lb. per ton. By the formula I proposed in my former article $\left(2.5 + \frac{V^2}{294}\right)$ it is 7.41, the actual resistance being just the mean between the two. In the next case (41) she gets on to the 1 in 348, and the speed begins to rise again, hence the high resistance here and in the following cases. The pull in these three cases comes down in spite of the acceleration, a point which will be discussed presently.

In cases 36 and 50, which are both at 60 miles an hour on the level, the speed seems fairly steady. The mean total resistance of the two is 14.73, the result of my formula being 14.74.

Case 51 is very interesting; the speed and pull are the same as in 50, hence the extra 130 horse-power is all debited to the engine. Of course its true resistance did not change like this, it is the effect of deceleration. I offer an explanation later.

The initial pull of 12½ tons on leaving Rugby looks very well, but I suspect it merely records the effect of a violent jerk on the apparatus.

Cases 56 to 58 are peculiarly interesting, and will repay a careful study. Before considering them in detail, I wish

TABLE.

1	2	3	4	5	6	7	8	9	10	11	12	13
Case.	Miles from Euston.	Gradient 1 in ... (up).	Speed.	I.H.P.	M.E.P.	Pull in tons.	H.P. absorbed by engine.	H.P. absorbed by carriages.	Percentage absorbed by engine.	Resistance in lb. per ton with gradient eliminated.		
										Engine.	Carriages.	Total.
1	5½	Level	51 +	1000·7	114·6	2⅝	277·18	723·52	27·7	21·07	14·88	16·12
5	15	,,	54	1140·71	123·4	2¼	334·31	806·4	29·4	24·	15·66	17·33
6	21	508	59 −	1043·71	103·3	2⅝	206·7	837·01	19·8	9·16	10·47	10·21
7	25	335	57 −	1096·68	112·4	2½	245·48	851·2	22·4	10·01	8·98	9·19
8	28	335	55 −	1200·76	125·4	2⅝	338·36	862·4	28·2	17·16	9·76	11·26
9	30	335	52 −	1078·08	121·1	2 9/16	282·12	795·96	26·2	14·34	9·37	10·36
11	51½	Level	74½ −	1123·2	88·1	1 7/16	290·77	832·48	34·9	15·13	11·75	12·43
12	53½	,,	72½ −	998·5	80·4	1⅜	204·97	793·53	20·5	10·96	11·75	11·59
20	90	,,	64	1229·25	112·2	2 7/16	297·41	931·84	24·2	18·01	15·27	15·82
36	148	,,	60	1112·91	108·3	2⅜	261·71	851·2	23·6	16·9	14·88	15·28
37	157¾	Level	16 +	547·62	199·9	4½	117·54	430·08	21·5	28·47	28·2	28·25
38	156	269	33½ +	917·45	160·	3½	194·75	722·7	21·2	14·21	14·39	14·35
39	154	269	41½ +	1065·81	146·5	3 5/16	229·17	836·64	21·5	13·08	12·82	12·87
40	152	177	38	949·06	148·9	3½	239·73	709·33	25·2	11·79	6·93	7·9
41	150	348	38 +	991·28	155·4	3½	253·57	737·71	25·6	19·19	13·93	14·98
42	148½	348	43 +	1063·92	144·5	3	293·36	770·56	27·6	20·01	12·36	13·89
50	90	Level	60	1041·76	101·4	1⅞	369·76	672	35·5	23·89	11·75	14·18
51	86	,,	60 −	907·26	88·3	1⅝	235·26	672	25·9	15·2	11·75	12·44
56	35½	333	53 −	969·01	106·8	2 7/16	276·48	692·53	28·5	13·49	6·98	8·28
57	34	333	50½ −	904·03	104·6	2 5/16	203·46	697·57	22·8	9·12	8·55	8·66
58	32½	333	49 −	869·93	103·7	2⅜	174·78	695·15	20·1	7·1	8·94	8·57

to make some remarks as to what happens generally when the speed is varying.

A glance at these kind of diagrams shows that the tendency is for the line of pull to correspond in direction with that of the gradient, while the line of speed is opposite to it. It does not seem altogether clear at first sight why this should be so; one may say it is natural for the speed to fall going uphill, and rise going down, but why should the pull go the other way? The resistance must decrease as the speed falls; but, nevertheless, the pull always rises when the train is going up a gradient too steep for the engine to maintain the speed. The natural tendency is for the indicated horse-power to vary directly with the speed (it does so exactly when the M.E.P. is maintained), and the resistance comes down faster than the speed. Yet we have this apparent contradiction. The answer is, kinetic energy. There is at any given instant a certain energy stored up by virtue of the velocity, say, K in the engine, and k in the carriages. If deceleration is going on, this is being drawn upon, and the total resistance works out below its real value; in the same way, when accelerating, energy is being stored up, and the indicated horse-power developed is more than would be merely required to overcome the resistance appropriate to the speed. And when the speed is varying, the apportionment of power between the engine and carriages is affected also in the following manner. Suppose there is deceleration; the pull is below its real value for the speed, and the kinetic energy is being drawn upon. Since the weight of the carriages is four times that of the engine, but K + k is being diminished as a whole, there is an additional negative influence on the pull, owing to the assistance the engine is receiving from the carriages, which reduces the pull still more; but this tendency becomes rapidly less, since the kinetic energy varies with the square of the speed. This is, I think, why the pull rises.

On the other hand, when accelerating and storing up energy, the engine is only pocketing one-fifth of it herself, and giving up the other four-fifths to the carriages, which again affects the figures, the pull starting above its proper value, and coming down. Thus there are two opposing influences on it. For if we consider it composed of two parts, m that which overcomes the resistance appropriate to the speed, and n that which produces acceleration, m rises as the speed is increased, and n drops even if the acceleration is uniform, for the reason just given, which is shown by the fictitious decrease in the pull and increase in the apparent resistance of the engine. This occurs in cases 40, 41, 42, and the opposite, when deceleration is going on, appears in cases 50, 51, and 56, 57, 58. That it is fictitious is certain, because the amount of pull required to maintain a uniform rate of acceleration is, of course, really constant, being practically equal to $\frac{m\,a}{g}$, as will be shown later.

This is the chief cause for the great variations in column 10. The average of the whole 61 cases works out to 25.7, a feature on which Mr. Cooke is much to be congratulated, as the result of previous investigations is that the engine usually absorbs at least 34 per cent. of the power. If I were asked to hazard a guess as to the particular feature which contributes most to this excellent result, I should say piston valves.

One would expect the values to be greater at higher speeds, on account of the increased wind resistance on the engine. I have tried this, with a very curious result. The average of those under 50 miles an hour—which, by the way, are nearly all accelerating—is 23, while the averages of those (a) at 50 to 59, (b) at 60 to 69, and (c) over 69, all come almost exactly to 26.

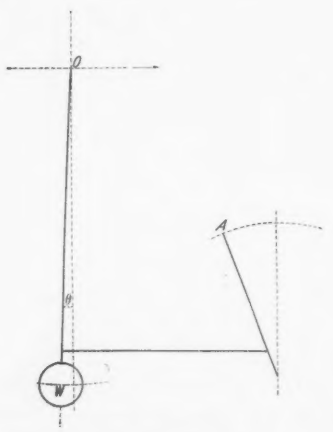
With regard to a formula, I think nothing is to be gained by complication, and that the Clark form is best. I therefore suggest the following:—

When velocity is uniform (a) $R = 2.5 + \frac{V^2}{294}$;

When velocity is variable (b) $R = 2.5 + \frac{V^2}{294} \pm 70\,a$;

(c) $R = 2.5 + \frac{V^2}{294} \pm \frac{A}{35}$

Here a is the acceleration in feet per second per second, and A the same in miles per hour per hour. The value of the acceleration can be determined by means of an "accelerograph," represented here diagrammatically.



A heavy weight W is hung from a pivot at O, preferably from the roof of the car. It will require guiding when the latter is running round a curve. I think a horizontal wheel should be attached underneath, running between two guides adjusted at such a distance apart that when the wheel bears against one it is just out of contact with the other. At A there is a pencil tracing a line on the roll of paper, assuming the latter to be travelling vertically here. Any suitable arrangement may be employed for the connection to the pencil, the two conditions to be satisfied being (1) large multiplication of motion, (2) absence of backlash. Probably a dashpot arrangement would also be necessary.

The angle θ depends on gradient + acceleration. If the gradient is known, the acceleration can be found. If the train is at rest, or moving with uniform velocity, the gradient can be checked. If the locomotive has a speed indicator, and is carefully driven over a piece of line at any steady speed, the instrument will give a record of all the gradients.

When coasting, the retardation shown by the instrument $\times \frac{2240}{g}$ gives the resistance in pounds per ton at the corresponding speed.

Suppose the train is travelling on the level in the direction of the arrow with an acceleration a feet per second per second, m being the mass of the pendulum, the pressure on O in the direction O W is $m\,g \sin\theta$. Resolved in the horizontal direction this is $m\,g \sin\theta \cos\theta$. This is equal to the accelerating force $m\,a$.

Hence, $$\sin\theta\cos\theta = \frac{a}{g}; \quad . \quad . \quad . \quad . \quad (1)$$

And as $$\sin\theta\cos\theta = \frac{1}{2}\sin 2\theta;$$

$$\sin 2\theta = \frac{2\,a}{g}. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Hence, strictly speaking, the effect of acceleration, or the reverse, on the resistance is the same as an additional gradient of an angle equal to $\frac{1}{2}\sin^{-1}\frac{2\,a}{g}$. But we are dealing with such small angles that cos θ may be taken as unity, and the equivalent gradient as $\sin^{-1}\frac{a}{g}$ (from 1).

The resistance corresponding to this is $\frac{2240\,a}{g}$ lb. per ton.

The gradient scale will be constructed by jacking up the car at different angles. From this the acceleration scale can be calculated.

To return to cases 56 and 58. The train was running up the 1 in 333 bank to Tring. The speed fell, and the pull on the drawbar went up in almost exact inverse proportion, keeping the horse-power absorbed by the train constant, a phenomenon which is merely accidental. It is a pity the scale of the pull is not larger, variations under 140 lb. not being shown, which means about 18 horse-power at 50 miles an hour. The engine could not quite maintain the steam pressure, the indicated horse-power falling more rapidly than the speed.

If we assume the deceleration uniform approaching case 57, since $a = \frac{u^2 - v^2}{2\,s}$, where u and v are the two velocities and s is the space travelled over, $a = \frac{207 \times 5}{12} = 86\frac{1}{4}$ miles per hour per hour.

Between cases 57 and 58 it dropped 1¼ miles an hour in 1¼ miles, which at first sight looks like 60 miles per hour per hour, but is really in this case 49¾. The mean of these two is 68. Let us assume that this was the deceleration at case 57. Turned into feet per second per second, it is .0277. Hence $\sin\theta = \frac{.0277}{g} = .0008605$ (θ is just under 3′.)

The corresponding resistance is 2240 sin θ = 1.93 lb. per ton. The apparent resistance was 8.66, making the true value for 50½ miles per hour 10.6. By my formula (a) it is 11.17.

Cases 7, 8, and 9 are running up the other side of the same bank. The acceleration in case 8, calculated in the same way as before, works out to $58\frac{12}{14}$ miles per hour per hour, and my formula (c) gives 11.11, the observed resistance being 11.26.

Postscript.—Since writing the above I find that my idea of a pendulum accelerograph has been anticipated by Mr. F. W. Lanchester, having been communicated to the Physical Society some years ago. It is most surprising that the invention should not have been turned to practical use by railway engineers, as it seems to me it would be a most valuable addition to a dynamometer van.

THE DESIGN OF CAMS FOR HIGH-SPEED MOTORS.

By ROBERT F. McKAY, M.Sc., A.M.I. Mech. E.

NOTWITHSTANDING the many improvements effected in high-speed internal combustion engines during recent years, there does not seem to have been very much attention paid to the action of the cams in operating the inlet and exhaust valves, &c. Although the cams no doubt fulfil the main function for which they are intended, a closer analysis shows that they have many defects that it is possible to remove by a modified design.

The chief points to be taken into consideration in the design of cams are

(1) Angle of cam action to obtain the requisite lift.
(2) Lateral pressure exerted by the cam.
(3) Force required to accelerate the moving parts of the valve, &c.

The type of valve gear to be considered in this paper is that in most general use on petrol motors, viz., the valve is actuated by a cam through an intermediate vertical spindle known as the jumper-rod. The bottom end of the jumper-rod is fitted with a roller which rests on the cam. The cam is fixed to a cam shaft which rotates at one-half the speed of the crank shaft.

The type of cam usually fitted for operating the inlet valve of high-speed engines is shown in Fig. 1. The sides of the cam are straight and the top is rounded off. It is proposed to consider a valve which requires a lift of ⅜in. To attain this lift a cam is taken whose total angle of action is 130 deg. This angle usually varies from about 122 deg. to 130 deg., being smaller when the amount of lift required is smaller. The valve diagram for the cam selected is shown in Fig. 1, the shaded portion of the figure representing the valve displacement on a circular basis. This diagram is better understood if it is assumed that the cam remains still and that the roller moves round it.

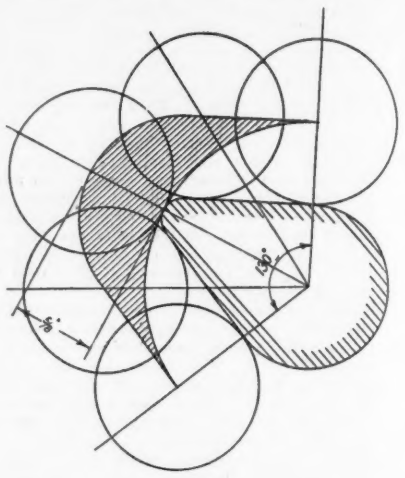


Fig. 1

(1) *Angle of cam action.*—As the cam shaft rotates at one-half the speed of the crank shaft, the angle of cam action should be exactly 90 deg. if the valve is to open and close at exactly the end of each stroke of the piston. Now, a cam action of 130 deg. corresponds to a movement of the crank through 260 deg., *i.e.*, 40 deg. on either side of the dead-centre. Referring to Fig. 2, it will be seen that for this crank angle the displacement of the piston from the end of the stroke is considerable. (In this figure the effect of the obliquity of the connecting-rod is neglected.) Although it is theoretically wrong to open the inlet valve so much before the beginning, and close it so much after the end, of the admission stroke, it is found necessary to do so with the existing type of cam in order to get the requisite lift for the valve. In petrol engines, or any high-speed engine where the fuel enters the cylinder under induced pressure, it is important that every precaution should be taken to prevent the vapour from being throttled as it enters the cylinder. The greater the bulk of gas admitted the higher will be the power developed by the engine.

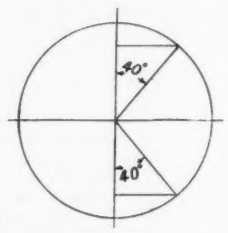


Fig. 2

In order to get a maximum supply of fuel into the cylinder it is at present necessary to give a large lift to the valve, and consequently have a large angle of cam action. Alternatively, in place of increasing the lift of the valve, the rate of opening the valve would have to be considerably augmented. In this respect, therefore, that cam is most efficient which gives the valve its maximum opening in the shortest time, and so allows it to remain full open for the longest period during a given angle of cam action.

It will be noticed that in the given example the angle of cam action cannot be materially reduced if the lift of ⅜in. is to be maintained. In order to give the bare lift of ⅜in., an inclusive angle of 120 deg. must be employed—see Fig. 3—and the top of the cam would then be left pointed. This is not permissible, for practical reasons. Hence it is clear that, making an allowance for a radius on the cam at the top, the valve only remains approximately full open for a few degrees in a total angle of cam action of 130 deg. Of course the rate of opening the valve could be augmented by increasing the slope of the cam face, but it will be seen in (2) that this only increases what is already a bad feature in the design.

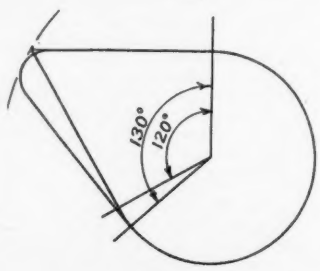


Fig. 3

(2) *Lateral pressure on jumper-rod bearings.*—From Fig. 4 it will be seen that a large proportion of the force exerted by the cam in lifting the roller is expended uselessly on lateral thrust, and that the wider the valve is open the greater is the power lost in this way. This lateral thrust occurs on both the up and down stroke of the valve, and so causes wear on

both sides of the jumper-rod bearings. Hence, not only does the presence of lateral thrust increase the power necessary to lift the valve, but it also causes excessive wear of the jumper-rod bearings, which, in turn, is the cause of much of the objectionable rattling usually connected with all jumper-rods on any but new engines.

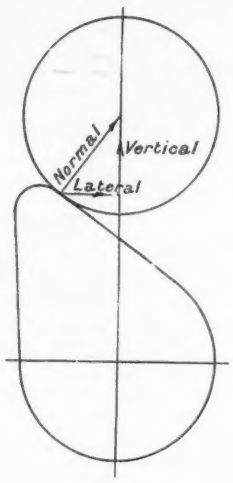


Fig. 4

(3) *Force required to accelerate the moving parts of the valve, &c.*—Since the valve is at rest during part of the revolution of the cam shaft, it will require a force to accelerate it to its maximum velocity, and will give out a force as it comes to rest at the top of the lift. The force exerted by the cam on the jumper-rod may, therefore, be divided into two parts, that necessary to accelerate the moving parts, and that necessary to overcome the load on the valve due to the spring which keeps the valve in place. Although the mass of the moving parts is small, the speed may be high and the accelerating force considerable. It is desirable to prevent the accelerating force at any point from being excessive, so that the scantlings of the rods, pin-joints, &c., may be reduced to a minimum, and so that the engine may work smoothly.

Some criticism may here be directed to the cams given in many text-books which are supposed to impart uniform lift to the valve during the rotation of the cam-shaft. The lift being uniform, the speed of the valve must be constant, and the acceleration, therefore, zero during the whole of the lift. Hence, at the moment the cam begins to move the valve, an infinite accelerating force must act so as to give the valve a uniform velocity. This is obviously impossible, and the practical result would be that the cam would jamb instead of lifting the valve. In theoretical questions on cams, it can be assumed, either that the cam imparts harmonic motion, or that it causes a uniform acceleration during the first half, and uniform retardation during the second half of the valve stroke. In the first case the displacement curve is a double sine curve, and in the second a double parabola. The condition determining the shape of the cam must never be that of uniform lift during the rotation of the cam shaft.

The accelerating or retarding forces necessary to move the

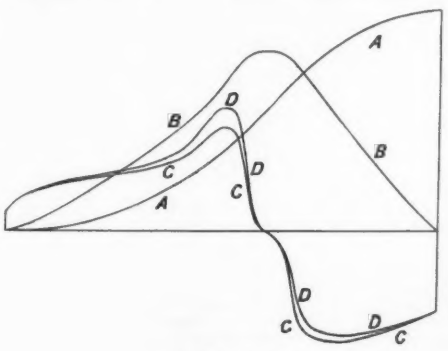


Fig. 5

valve and bring it back to rest are best shown in a graphical manner. For the valve chosen this is done in Fig. 5. To a base of cam angles, the displacement curve of the valve is shown at A A. As the cam is symmetrical, the displacement curve for the upward lift only has been shown. The velocity curve B B is found by differentiating the displacement curve —*i.e.*, setting up ordinates at various points whose lengths are proportional to the tangents of the angle of slope of the displacement curve at each point. Differentiating the velocity curve in the same manner, the acceleration curve C C can be drawn. The ordinates of the acceleration curve will be directly proportional to the accelerating force at each point. As the net work done by the accelerating and retarding forces is zero, the area of the acceleration curve above the base line will just be equal to the area below. On account of the obliquity of cam action—see Fig. 4—the accelerating force actually exerted by the cam will be greater than the preceding, while the retarding force is lessened. The curve showing the actual forces is shown at D D, and it is clear that the net balance of work is positive—*i.e.*, on account of the obliquity of cam action, more work is done in accelerating the moving parts than is afterwards recovered during their retardation.

The acceleration curve C C or D D shows the comparative amounts of the accelerating forces at various points. The actual amounts can be obtained by paying careful attention to the various scales of the drawings.

Let W = Weight of moving parts in pounds
N = Revolutions per minute of the engine
Then $\frac{N}{120}$ = Revolutions per second of the cam shaft

and 3 N = Number of degrees moved through by the cam shaft per second, *i.e.*, the cam turns through an angle of 1 deg. in $\frac{1}{3\,N}$ seconds.

In the displacement curve let 1in. horizontal represent a degrees of cam action, *i.e.*, represent $\frac{a}{3\,N}$ seconds.

Let 1in. height represent b inches valve displacement, *i.e.*, $\frac{b}{12}$ feet.

Then tangent of angle of slope of 45 deg. to displacement curve represents $\frac{\frac{b}{12}}{\frac{a}{3\,N}}$ feet per second, *i.e.*, $\frac{b\,N}{4\,a}$ feet per second.

Now, let 1in. height on the velocity curve represent angle whose tangent is c, *i.e.*, a velocity of $\frac{b\,c\,N}{4\,a}$ feet per second.

Then tangent of angle of slope of 45 deg. to the velocity curve represents $\frac{\frac{b\,c\,N}{4\,a}}{\frac{a}{3\,N}}$ ft. per sec.^{2}, *i.e.*, $\frac{3\,b\,c\,N^2}{4\,a^2}$ ft. per sec.^{2}

Let 1in. height on the acceleration curve represent angle whose tangent is d, *i.e.*, an acceleration of $\frac{3\,b\,c\,d\,N^2}{4\,a^2}$ ft. per sec.^{2}

But accelerating force = $\frac{W}{g}$ × acceleration.

∴ 1in. height on acceleration curve represents an accelerating force of $\frac{W}{g} \times \frac{3\,b\,c\,d\,N^2}{4\,a^2}$ lb.

Take as an example a case where W = 8 lb., N = 500 revolutions per minute.

Let 1in. horizontal on displacement curve represent 6.5 deg. of cam action. Then $a = 6.5$.

Let 1in. vertical represent $\frac{1}{2}$in. valve displacement. Then $b = \frac{1}{6}$.

Let 1in. height on velocity curve represent an angle of slope on displacement curve whose tangent is $\frac{1}{4}$. Then $c = \frac{1}{4}$.

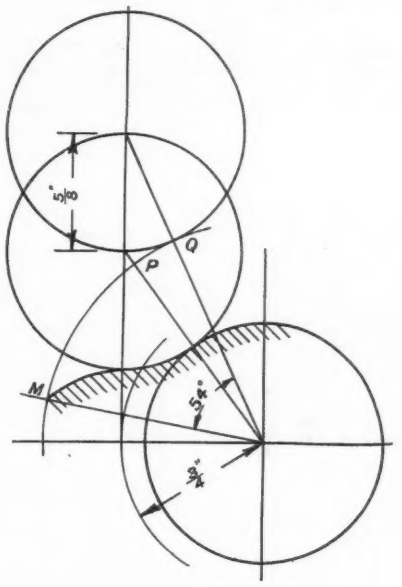


Fig 6

Let 1in. height on acceleration curve represent an angle of slope on velocity curve whose tangent is $\frac{1}{4}$. Then $d = \frac{1}{4}$.

∴ 1in. height on acceleration curve represents an accelerating force of $\frac{8}{32.2} \times \frac{3 \times (500)^2}{8 \times 4 \times 4 \times 4 \times (6.5)^2}$, *i.e.*, 8.6 lb.

The maximum height is 2.8in., representing a maximum accelerating force of 24 lb.

Having discussed fully the principal points to be considered in the design of cams by reference to the one selected, it is now desired to draw attention to another form of cam which will give the same lift as before of $\frac{5}{8}$in.

A very satisfactory shape of cam is got by the simple expedient shown in Fig. 6. The centre line of the valve is moved $\frac{3}{4}$in. to one side of the centre line of the cam shaft, and the driving face of the cam is made an involute of a circle of $1\frac{1}{4}$in. diameter. The result is that in opening the valve the pressure between the cam and the roller is always vertical in direction, and there is no power lost in lateral thrust except-

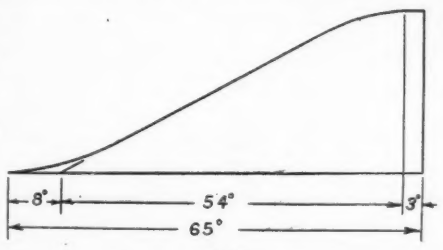


Fig. 7

ing a small amount when the top of the cam is travelling from P to Q, *i.e.*, when the valve is nearly full open. Not only so, but it will be found that the valve is full open when the cam travels from M to Q, *i.e.*, for an angle of cam action of 54 deg.—a substantial reduction on the previous type.

The shape of this cam must, however, be modified to meet a defect which is apparent on drawing the displacement diagram. It is found that the displacement is uniform during the greater part of the stroke, and that the velocity is therefore constant. Hence, as explained before, the accelerating force at the first point of contact of cam and roller must be infinite, *i.e.*, the cam would in practice jamb. Some modification is therefore necessary to the shape of the cam at the root in order to allow for the initial acceleration of the moving parts. A modified displacement curve is shown in Fig. 7. The full displacement can be attained in 54 deg. Suppose the valve remains full open 3 deg., and that the root of the cam be modified so that the angle of full lift is increased by 8 deg. The angle of cam action is then 65 deg., the same as in the example previously considered. The

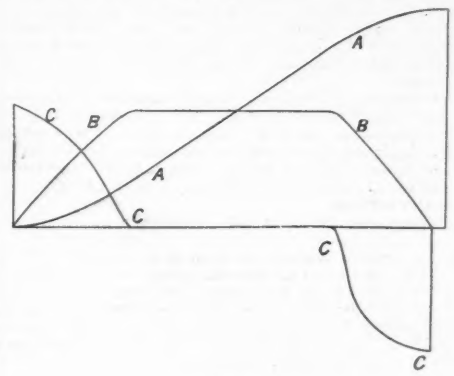


Fig. 8

displacement, velocity and acceleration curves under these conditions are shown in Fig. 8. It can be seen that the accelerating force is now no greater than that shown to the same scale in the previous example.

The actual shape of the cam can readily be determined when the displacement curve has been fixed upon. This is

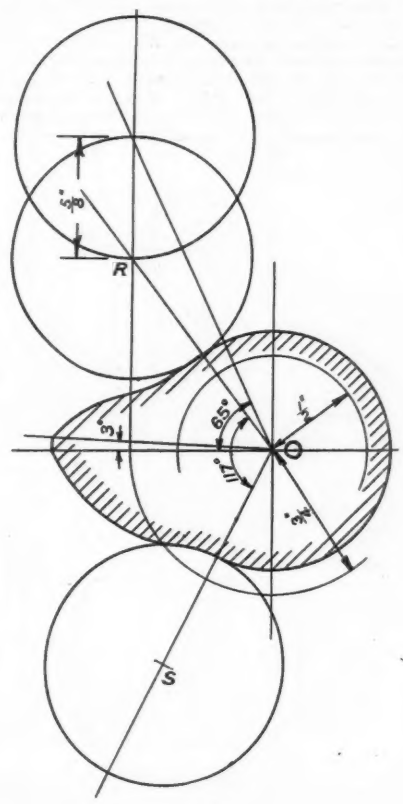


Fig. 9

shown in Fig. 9. The shape of the downward slope of the cam is determined chiefly by the fact that when the engine back-fires the cam must be able to lift the valve without causing an undue shock. This is attained if the face be made the involute of a circle of lesser diameter, say 1in. It is not necessary to modify the root of the cam on this slope.

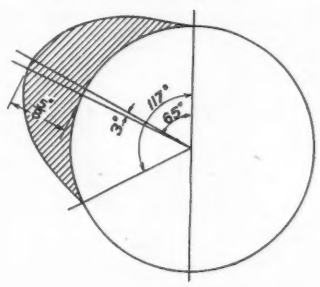


Fig. 10

Under these conditions lateral pressure will be introduced on the down stroke, but it will be a minimum when the valve is full open and a maximum at the closing of the valve, thus minimising as much as possible the wear on the jumper-rod bearings.

With the shape of the cam thus decided, it can be compared with the cam previously considered.

(1) *Angle of cam action.*—Although the angle to attain full lift was kept the same as before, it is clear from Fig. 10

that the total angle of cam action is the angle R O S = 117 deg. This is a considerable decrease on the previous angle of 130 deg., and would bring the piston appreciably nearer the dead centre when the valve opens and closes. Or if the angle of cam action be kept constant, the valve will remain full open for a longer period, and its lift could therefore be reduced without interfering with the amount of fuel entering the cylinder. The valve diagram is shown in Fig. 10.

(2) *Lateral pressure.*—Although there is a little lateral pressure at the beginning and end of each up stroke, it is very small and practically can be neglected. There is of course lateral pressure when the valve is descending or when the engine back-fires; but this pressure is exerted in one direction only. Hence there is less likelihood of having trouble with the jumper bearings. The lateral pressure while the valve is at rest will not cause any wear on the bearings.

(3) *Accelerating force.*—As already explained, the root of the driving face of this cam has been modified so that the maximum accelerating force is no greater than in the previous type. By increasing the angle of cam action above 117 deg., or by diminishing the lift of the cam, the maximum accelerating force for the involute type of cam may be considerably reduced.

In conclusion, although only one cam of each type has been compared in the preceding investigation, it will be found that an involute cam may be designed to replace any of the ordinary types of cams, whose advantages over its rivals are similar to those stated previously. There are no insuperable mechanical difficulties to be overcome in adopting this device. It would only be necessary to move the cam shaft $\frac{3}{4}$in. to one side of its present position, and that can be done in new designs of engines without much trouble.

NEW PUMPING STATION AT WALTON.

No. I.

ON Saturday afternoon last Mr. John Burns, the President of the Local Government Board, formally opened the new pumping station of the Metropolitan Water Board, which has been erected some 500 yards from the south bank of the Thames at West Molesey, and which is known as the Walton Pumping Station. This station was in contemplation before the Water Board came into existence, and forms part of a scheme originated by Mr. J. W. Restler, M. Inst. C.E., Deputy Chief Engineer of the Water Board, into which what are known as the Walton and Island Barn reservoirs also enter, though the latter was incorporated in the scheme at a later date. We shows not only the relative positions of the Walton and Island Barn reservoirs, but also of the Walton Pumping Station.

The original idea for the major part of the undertaking was embodied in a Bill brought before Parliament in 1896 by the late Southwark and Vauxhall Water Company. The Bill received considerable opposition, and was rejected. Two years later it was again introduced in

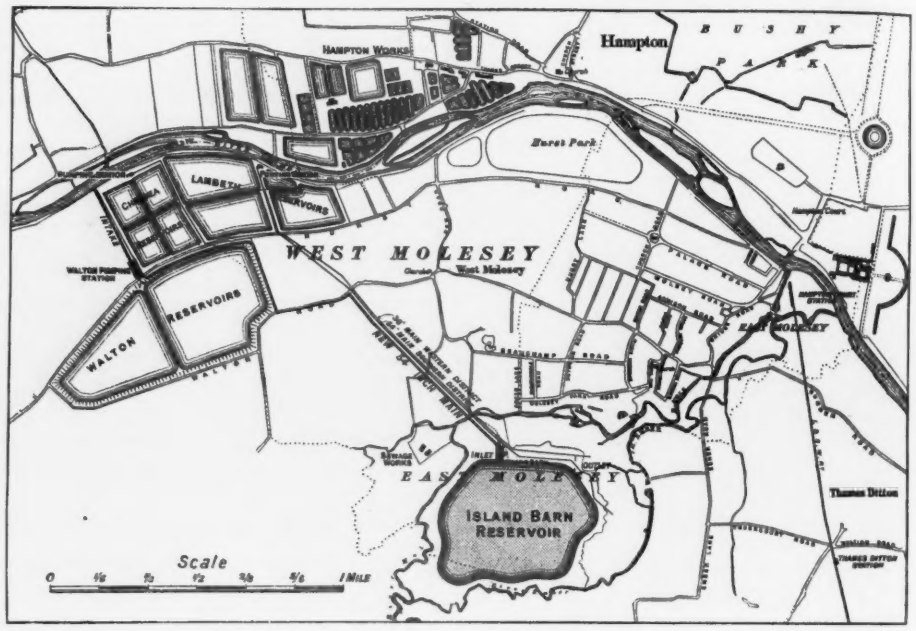


Fig. 1—MAP SHOWING POSITIONS OF RESERVOIRS, PUMPING STATIONS, AND FILTERS

June 24th, 1904, the Appointed Day, when the undertakings of the Metropolitan Water Companies was taken over by the newly constituted Water Board, the work had progressed to a considerable extent, but it was not until April 13th, 1907, that these two reservoirs were formally opened by Sir R. Melvill Beachcroft, the chairman of the Board. The two reservoirs together have a capacity of 1198 million gallons—the Knight, or western reservoir,

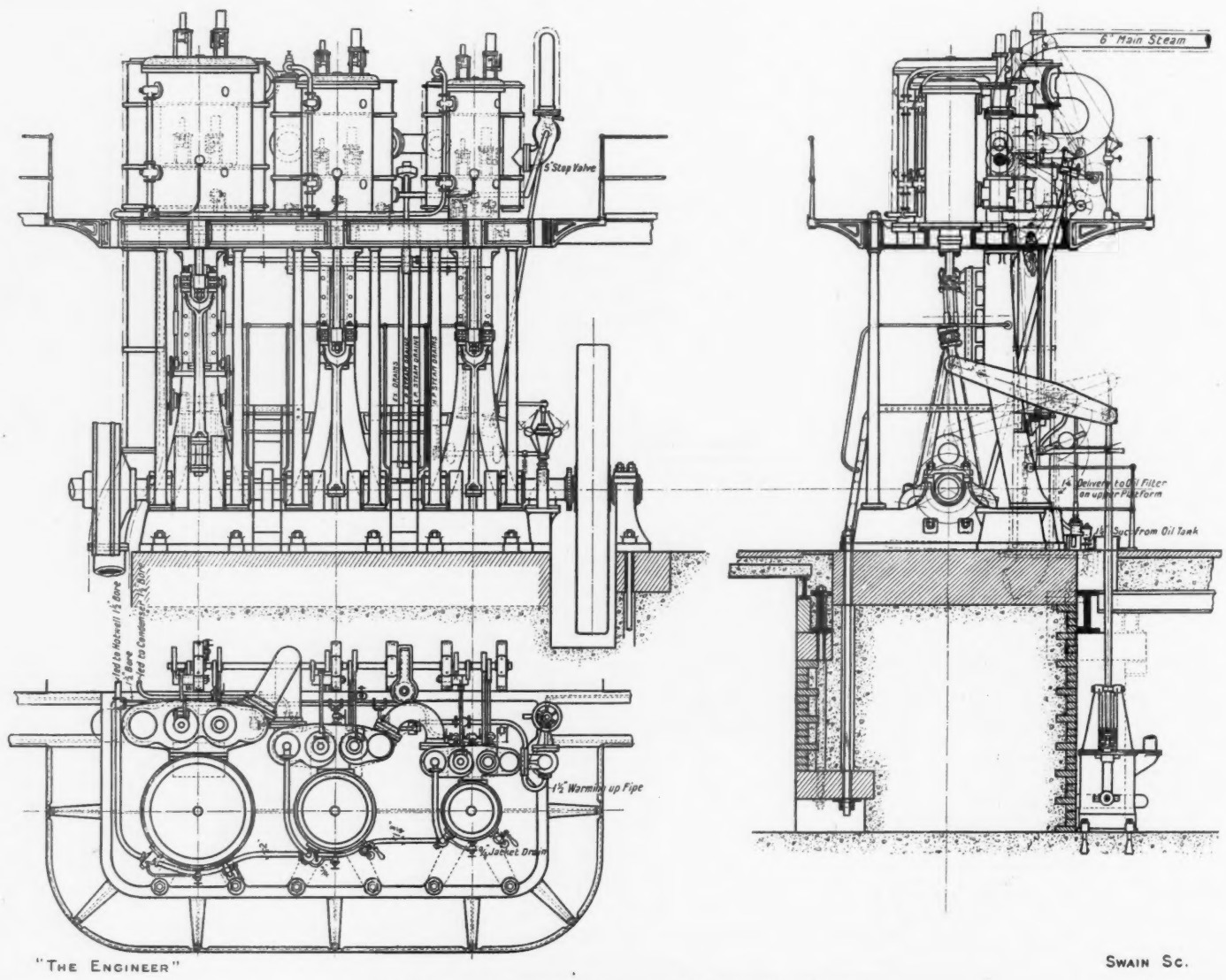


Fig 2—500 HORSE-POWER TRIPLE-EXPANSION PUMPING ENGINES

have alluded to these reservoirs on former occasions, notably in our issues of April 19th, 1907, and October 30th, 1908; but in order to render this account as complete in itself as possible, we may usefully recapitulate their chief features. Our remarks will be the more readily understood by reference to the plan map—Fig. 1—which a modified form, and under the title of the "Southwark and Vauxhall Act, 1898," received the Royal Assent on July 25th of that year. After some delay the first sod of the two Walton reservoirs, now known as the Knight and Bessborough reservoirs, was cut by Sir Henry Knight, the then chairman of the company, on April 30th, 1901. On 480 million gallons, and the Bessborough, or eastern reservoir, 718 million gallons, and taken together they cover a water area of 125½ acres. Their top water level is about 43ft. above mean river level.

When they were completed they had no pumping station of their own, though temporary arrangements had

been made for filling them from other stations of the Board, and they have been in service since they were opened.

Before we proceed to describe their own particular pumping station, which was opened on Saturday last, we should refer to the Island Barn Reservoir, with which it is to be linked up, and which, when completed, will form an essential part of the scheme. It may here be mentioned that the Water Board, in bringing these undertakings to a conclusion, has only completed work which was initiated by the water companies, and which would undoubtedly have been carried out by them—nearly certainly at a much earlier date—had they been allowed to continue in existence. The companies fully foresaw the large increase in demand for water which would take place in the London area, and were quite prepared to carry out their obligations and only make their statutory charges. We pointed out before the final decision to create the Water Board was arrived at that it was extremely unlikely that any economy would be effected by the change, and that in all probability an increase in the cost of the water supply would be experienced. By the adjusting of the scale of charges so that all parts of the water area now pay at the same rate, there are parts of the area where increased charges are in operation, though there have been reductions in others, but it would certainly seem that an additional levy on all consumers will have to be made.

But to return from this digression. The Island Barn reservoir, as it is now called, was originally planned by Mr. T. F. Parkes, the engineer to the Lambeth Waterworks Company, and received parliamentary sanction in 1900. Probably, by reason of the imminent change, the water company did not proceed with the work, and it was not till October 24th, 1908, that the first sod was turned by Mr. C. E. Hearson, the then chairman of the Works and Stores Committee of the Water Board. Prior to this an extension of time for the construction of the reservoir had been obtained, and several modifications made in the original proposals. With these, however, we need not at the moment be concerned. Suffice it to say that the reservoir will contain nearly 1000 million gallons of water and will have a water area of approximately 120 acres, with a top water level of from 36ft. to 38ft. above mean river level. Its construction, which is in the hands of Messrs. Robert McAlpine and Sons, is proceeding rapidly, and is now almost three parts finished.

Both the Walton reservoirs, as will be the case with the Island Barn reservoir when it is in service, can, as already explained, be filled from other pumping stations belonging to the Board, but it was always intended that the former should have its own pumping station, and the Water Board decided to make it serve the latter also. Consequently it had to be remodelled, and it is no doubt largely owing to this that the completion of the Walton pumping station has been so long delayed. It is, however, an exceedingly fine piece of work now that it is done.

It will be convenient, perhaps, if, in describing the station, we commence with the intake. This formed a part of the original contract for the Walton reservoirs, and was completed in 1907 by John Aird and Sons. We described it at the time, but we may now repeat that it consists of three tunnels under the towing path. These are commanded by three Stoney sluices made by Ransomes and Rapier, Limited, of Ipswich. They are worked by hand reduction gear from a footplate situated above flood level, and give access to three brick screen chambers which are provided with screens

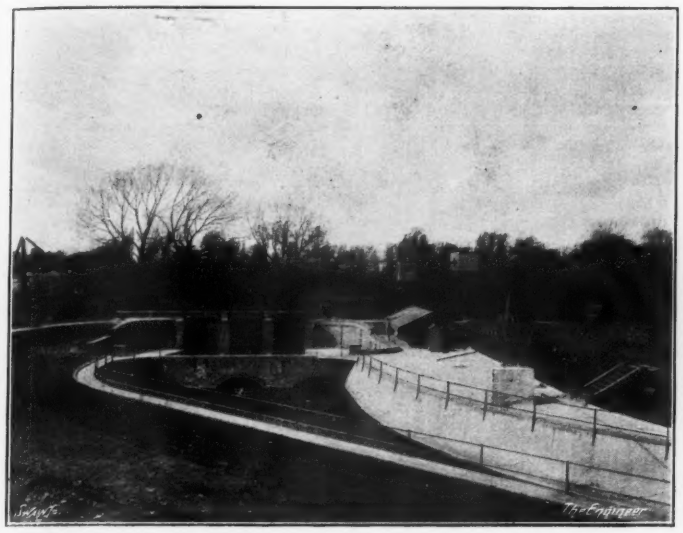


Fig. 3—JUNCTION OF CULVERT WITH SCREENING CHAMBERS

Fig. 4—THE SCREENING CHAMBERS AT THE INTAKE

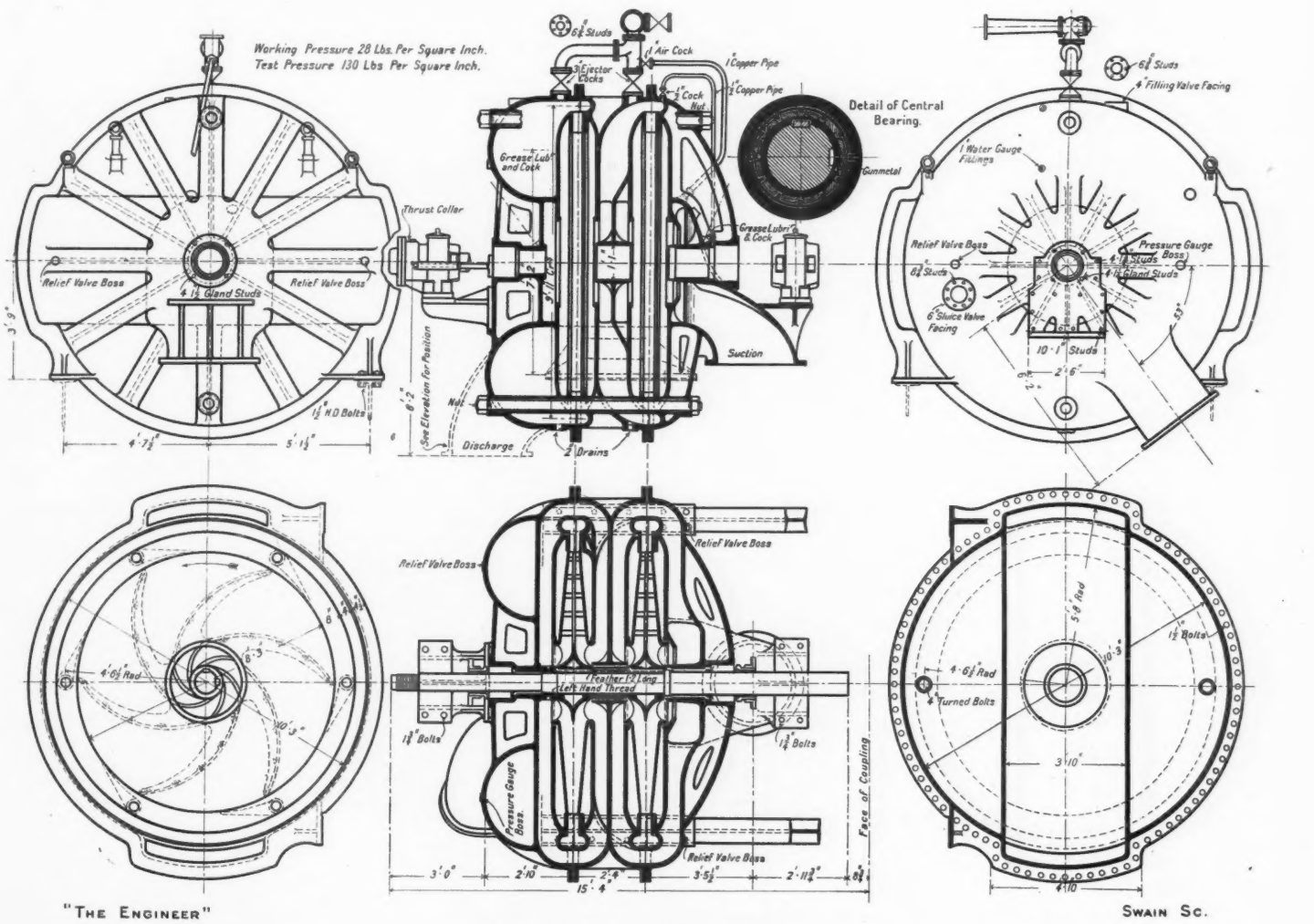


Fig. 5—TWO-STAGE CENTRIFUGAL PUMP

composed of stout iron bars arranged on edge and fixed at an angle sloping upwards away from the river. Originally the screen chambers were closed on the side furthest from the river by a brick wall, because the conduit leading to the site of the pumping station was not then made. This wall has now, of course, been pierced. Two views of the screen chambers and intake are shown in Figs. 3 and 4.

The conduit or culvert formed part of the contract for the pumping station buildings, which was entrusted to Dick, Kerr and Co., Limited. It is designed to convey 200,000,000 gallons of water per day, and is about 1450ft. in length. For the major portion of its length it is straight, but it joins the bay into which the three screen chambers at the intake deliver by two reverse curves. It is constructed of concrete, and from end to end of its length it is provided on both sides with a substantial handrail, and with chain life lines fixed just above water level. Arrived at the engine-house, the culvert is connected to a suction chamber which runs the full length of the building. Into it descend the suction pipes of the various pumps.

The buildings, the foundation stone for which was laid by Mr. Hearson on the same day that he cut the first sod of the Island Barn reservoir, are of a substantial character, and are constructed of red brick and stone. The chimney is specially noteworthy. It is square in section, and of a distinctly handsome shape, though it has aroused some criticism by reason of a somewhat deep stone course half way up. The engine-house, which is 185ft. long and 50ft. wide, is lined with white and green-glazed bricks, and is provided with a varnished wood roof carried on light steel principals. From end to end runs an overhead crane of 12 tons capacity, which is hand-worked from the floor level. The lighting is by means of sky-lights in the roof, and tall windows along the eastern wall and at the two ends. The floor is of concrete, with borders of glazed tiles round each of the machines. Let into the floor at various places are iron frames fitted with reflecting glasses for illuminating the floor below which

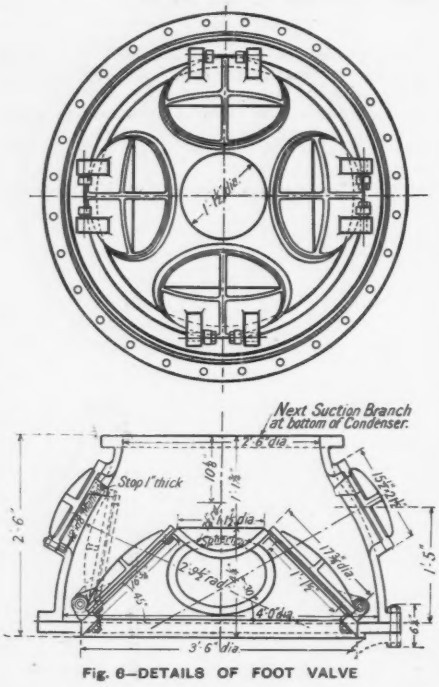


Fig. 6—DETAILS OF FOOT VALVE

contains the condensing arrangements, pipe work, &c., and to which attention will be drawn later on.

The pumping machinery may be divided into two divisions. In the first place there is that which lifts the water directly from the level of the culvert into the Knight and Bessborough reservoirs, or through some 1⅝ miles of 54in. pumping main into the Island Barn reservoir. There are four units detailed for this work, and they are duplicates of one another. Each consists of a triple expansion vertical marine type engine coupled to a double stage centrifugal pump. The three cylinders have diameters of 14in., 23in., and 38in. respectively, and the piston stroke is 30in. The engines run at a speed of 120 revolutions per minute, and with a boiler pressure of 200 lb. per square inch, they are designed each to develop some 500 horse-power. They, as well as the whole of the remainder of the machinery contract, were supplied by the Thames Ironworks Shipbuilding and Engineering Company, which had various sub-contractors, as will be hereafter mentioned, but which constructed at its own works the engines, air pumps, condensers, &c. The steam distribution in the engines is effected by Cole, Marchent, and Morley's type piston drop valves actuated from independent shafts by means of excentrics and slip gear. The general form of the engines is well shown in the engravings on page 620, and in the drawing—Fig. 2—and they do not call for any lengthy description. The cranks are 9in. in diameter, and are in interchangeable sections. The tail shaft carries a fly-wheel fitted with a circular barring rack, with which a small steam driven starting engine engages through a worm and worm wheel.

At the opposite end the shaft is extended and has fitted to it one half of a flexible coupling, in which the drive to the other half of the coupling is by means of belting. Immediately adjacent to each engine, but on the floor below is a surface condenser fitted with 660 brass tubes, having a total cooling surface of about 930 square feet. The condenser actually forms part of the suction pipe to the pump, but a by-pass arrangement is provided whereby a portion of the suction water can be diverted past it, so as if necessary to limit and regulate the amount of cooling water. An Edwards type air pump, also fitted on the lower floor, is driven by rods from a lever pivoted on the low-pressure crosshead. The engines are governed in the ordinary manner, and there is a special knock-off gear which can be instantaneously operated should any thing go wrong, and which opens the condenser to atmosphere and closes the main stop valve.

Connected to the engines through the flexible couplers are double stage centrifugal pumps, made by Gwynnes, Limited, of Hammersmith. These are interesting because of the shape of the casing, which is well shown in the engravings on page 620 and in the drawing, Fig. 5. A drawing of one of the foot valves is also given in Fig. 6. They are, by reason of their two impellers, balanced so that end thrust troubles are eliminated and are fitted with 30in. suction and 27in. delivery pipes. The pumps are in each case arranged immediately over the condensers. Each pump has a designed capacity of 25 million gallons of water pumped to a total head of 64ft. in 24 hours. This represents a total horse-power, leaving out friction, of rather over 335, so that there are some 165 horse-power available for overcoming friction in the rising mains and for other losses.

The other pumping engines are of an entirely different character, and add considerably to the interest of the station. We have stated above that the top water level in the Knight and Bessborough reservoirs is some 43ft. above river level. The original contract for these reservoirs included, in addition to the works already mentioned, the running of two lines of 48in. mains to the south bank of the river opposite the old Southwark and Vauxhall Company's works at Hampton. Here they descend in a shaft lined with cast iron to a tunnel 12ft. 6in. in diameter driven under the river. Through this the mains are taken to the north bank and connection made with the existing reservoirs and filter beds at Hampton. Now the levels of these are considerably lower than the levels of the water in the Knight and Bessborough reservoirs, the filters being little, if anything, above mean river level, and the idea occurred to Mr. Restler to make use of the energy of the falling water to pump further water from the intake channel into the Walton reservoirs. He accordingly decided to instal turbine-driven centrifugal pumps for this purpose.

THE ROYAL SOCIETY.

Last Wednesday the Royal Society held its second annual conversazione at Burlington House. Although very few of the exhibits were related to engineering, many things were shown of considerable scientific interest, and several are worthy of being brought to the notice of our readers. Perhaps the most interesting exhibits from an engineering standpoint were the photographs of the new Experimental Tank at the National Physical Laboratory, which were shown by Dr. Glazebrook. As is now well known, the National Experimental Tank has been constructed for carrying out experiments on models of ships. The main tank is 550ft. long by 30ft. wide and 12ft deep. The models will be towed along it from a carriage, electrically driven, which spans the tank. There is also a small tank 63ft. in length, in which experiments can be made with flowing water. The photographs on view also illustrate these tanks, and also the model moulding and shaping machinery, the models being made of paraffin wax.

Sir James Dewar's exhibit demonstrated how the motion of a radiometer is stopped by a very high vacuum. A radiometer was placed in a concentrated beam of an electric arc, and the motion was stopped by a charcoal liquid air vacuum, and started again by mercury vapour given off by liquid mercury between the ordinary temperature and — 25 deg. Cent., or at a limiting pressure of about one fifty-millionth of an atmosphere. Activity was again arrested on freezing out the mercury vapour by liquid air. Mirrors formed by mercury distilling at the ordinary temperature were also on view.

Professor Silvanus P. Thompson and Professor E. G. Coker were showing some apparatus for carrying out experiments with polarised light. There was a large polariscope having a field 12in. square, the polariser being a sheet of blackened glass. Large scale experiments on optical stress in materials were shown. The objects to be subjected to stress are cut out of xylonite, a substance which in polarised light shows the effects of stress by the production of interference colours of various orders. There were also quarter wave plates of mica, cut from clear sheets of mica, supplied by Messrs. Wiggins. The largest is 19in. in diameter. The two used in the experiments on stress, to produce an approximately circular polarisation of the light, are each 12in. square. Lastly, there were large scale polariscopic objects of mica, selenite, and unannealed glass.

Dr. Deane Butcher was exhibiting examples of osmotic growths. Osmotic growths are mineral productions simulating the forms of organic life. They are obtained by sowing a mineral seed or nucleus in a concentrated inorganic mother liquor. The nucleus reacts with the liquid to form an insoluble gelatinous precipitate at the surface of contact. This semi-permeable extensible membrane is distended by the osmotic pressure within, and grows by a process of intussusception, branching and putting forth terminal organs as it reaches a solution of lesser concentration. Osmotic growths were first described by Professor S. Leduc in his work on the "Mechanism of Life."

A collection of radiometers and otheoscopes was exhibited by Sir William Crookes. These experimental instruments were made by the exhibitor during his researches on "Repulsion Resulting from Radiation," and were used to illustrate the papers when they were read before the Royal Society in the years 1875-78. Since 1878 they have been packed away in a cupboard, and only within the last few months have they been brought to light.

The Astronomer Royal exhibited a globe showing the motions of the two main star streams. The model was constructed to show how an examination of the directions of motion of the stars reveals the presence of two great streams of stars. The statistics of the motions in different parts of the sky are summarised by the diagrams on the globe; it can be seen that for each region there are two "favoured directions" of motion in which the stars move in greatest numbers. These directions are traced on the globe, and converge to two apices. The complete investigation is based on the motions of about 6000 stars distributed all over the sky, recently published by Professor Boss. The diagrams reproduced on this model correspond to rather more than half of the whole data.

Some photographs and living cultures of *Bacillus Phosphorescens*, showing the germicidal action of some metals, were exhibited by Mr. Henry Crookes. Nutrient gelatin-agar is poured into Petri dishes containing small pieces of metal; when the medium has set, the surface is infected with *B. Phosphorescens*. After twenty-four hours the bacteria grow luxuriantly, except in a zone surrounding the piece of metal which remains entirely sterile. The extent of this death-zone varies with different metals. The plates and photographs exhibited included silver, mercury, antimony, thallium, copper, gold, platinum, &c. Other bacteria are affected in the same manner. The materials having no germicidal action are gold, platinum, palladium, rhodium, iridium, tantalum, cadmium, magnesium, tin, graphite, and selenium. Sulphur appears to have a stimulating action. Metals having a slight germicidal action are bismuth, lead, nickel, iron, aluminium, zinc, copper, and those having a strong germicidal action are thallium, cobalt, silver, mercury, antimony, and arsenic; chloride of silver, bromide of silver, cyanide of mercury, mercuric chloride ($HgCl_2$), and arsenious acid, are among other bodies having a strong action. In the case of some metals, such as silver, mercury, cobalt, and lead, there is a bright ring surrounding the death zone; this has been shown by experiment to be due to the stimulating effect of a very small dose of the poison—about 20 to 25 parts per million. Other bacteria—such as *B. Coli communis*, *B. Prodigiosus*, &c.—and also moulds, are equally affected by this poisonous action of metals; photographs of several of these were also shown. *B. Phosphorescens* has been generally used for experimental purposes, as the results are so easily observed and photographed.

Ship Repair by Oxy-acetylene Welding.—The steamer J. W. Taylor had been in collision, and the stem was so badly bent that it was impossible to straighten it into position. It was therefore cut about 12ft. below one of the scarf joints, removed and straightened in the shop, replaced, and then welded into position by the British Autogenous Welding Company, Limited, of London, and passed by Lloyd's local surveyor. The section of the stem is 10in. by 3in., and the total time occupied in welding was nine hours, thus enabling the steamer to take her turn at the coal tips on time. This repair, which was effected at Sunderland last week, was carried out at a total cost of about £60, and saved the steamer some eight or ten days' detention.

International Association for Testing Materials.—The sixth Congress of the International Association will be held in New York City and in Washington in the beginning of September, 1912. Six days have been allotted to the sittings; arrangements will also be made for members to take part in the deliberations of the Congress for Applied Chemistry to be held there at the same time. In connection with the Congress excursions will take place, which will likewise last about six days. This Congress, for which a large number of important papers have already been promised, will be held under the auspices of the powerful American Society for Testing Materials, and of the American great industries. The president of the International Association (Professor Henry M. Howe) will act as president of the Congress; the secretarial duties are in the hands of Professor Edgar Marburg, of Philadelphia.

The Mid-Scotland Ship Canal.—At a meeting of the Glasgow executive of the Scottish Ship Canal, held in Glasgow on June 12th, Messrs. D. A. Stevenson, C.E., Edinburgh, and C. P. Hogg, C.E., Glasgow, the joint engineers, reported that they were engaged upon the details of a joint report on the route (the direct route from Grangemouth to Yoker) and the level to be fixed for the canal at high water. They were arranging for borings to be made down to the rock along the bottom of the valley to enable close estimates to be made and the practical cost of construction ascertained. They were agreed that the canal must have a floor width of 148ft. and a depth of 36ft. between the gates, to satisfy the Admiralty. They were considering the exact point near to Yoker at which they would recommend that the canal should enter the Clyde. They hoped soon to have a joint report to present. It was pointed out by the chairman, Mr. Arthur Kay, that borings and plans and secretarial work would cost money, and as the scheme had now reached a point at which an appeal should be made for a guarantee fund to meet the preliminary expenses, it was agreed that the executive should take the necessary steps for raising this fund to be administered under the Glasgow committee.

Royal Meteorological Society.—The second afternoon meeting of this Society for the present session was held on Wednesday, the 14th inst., at 70, Victoria-street, Westminster, Dr. H. N. Dickson, president, in the chair. Dr. C. Chree, F.R.S., read a paper giving the results of a discussion of the barograph records kept by the late Mr. R Bell, at Castle O'er, Dumfriesshire, during the seven years 1902 to 1908. These results show a well-marked principal maximum and minimum at 10 p.m. and 5 a.m. respectively. Every single year agrees in this except 1908, which puts the maximum at 7 a.m. The existence of a secondary maximum and minimum is unmistakable, but while the hour of occurrence of the former is clearly 11 a.m., that of the latter is less distinct. It seems to be 4 p.m., but a longer series of observations would have been necessary to confirm this. Mr. Spencer C. Russell gave an account of a number of interesting experiments which he had carried out at Epsom during the last two years, in order to obtain a permanent record of the variations in the size of raindrops as, and when, they occurred. The first method employed was the exposure of a number of ruled slates divided into ¼in. sections and gently brushed over with an even coating of oil. This was not altogether satisfactory, as during heavy rain the drops impinged upon the slate with such force as to become broken up into a series of drops composed of one large and a number of small ones. The most satisfactory results, however, have been given by the use of plaster of Paris. Mr. Russell exhibited to the meeting a number of these raindrop models. He stated that the sizes of the drops which he had already collected were 7 of 6 mm., 44 of 5 mm., 73 of 4 mm., 222 of 3 mm, 257 of 2 mm., 175 of 1 mm., and 107 of less than 1 mm. A joint paper by Mr. A. J Makower, Dr. W. Makower, Mr. W. M. Gregory and Mr. H. Robinson was read, describing the experiments which they carried out last August at Ditcham Park, near Petersfield, in Hampshire, to investigate the electrical state of the air at different heights above the ground by means of kites and balloons.

RAILWAY MATTERS.

PLANS have been prepared for large new repair shops for the Canadian Pacific Railway at Coquitlam, British Columbia. It is stated that the shops will extend for nearly two miles.

THE North-Eastern Railway Company is about to have constructed a single line of railway about 1¼ miles in length at Ponteland. It is to be called the Little Callerton Railway.

THE concluding meeting of the Railway Club for the present session was held on Tuesday, June 13th, when the president, the Rev. W. J. Scott, delivered a lecture on "Railway History in the Middle Ages, 1860-80."

FROM the report of the Antofagasta and Bolivia Railway we note that the gross earnings per train mile during 1910 were 13s. 2d., against 13s. 7d. in the previous year; working expenses per train mile were 6s. 7d., against 6s. 8d.; and the net earnings 6s. 7d., against 6s. 11d.

ACCORDING to the *Contract Journal* a bridge is proposed over the Ganges at Mokameh, at a cost of 10,000,000 rupees, which will take four years to build. The East Indian and the Bengal and North-Western Railway Companies and the Government of India are interested in the scheme.

DURING the past year the Antofagasta and Bolivia Railway Company opened its new workshops at Mejillones, which necessitated moving all the staff and most of the machinery from Antofagasta. With the new conveniences now at the company's disposal, the repairs to locomotives are greatly facilitated.

THE Pennsylvania Railway will, it is announced, shortly build 77 locomotives at its Altoona shops. This is only one of the recent indications pointing to the possibility of railways in the United States building in the future at least a part of the locomotives required by them, instead of relying entirely on outside makers for the whole of their new construction.

THE estimates of the Blackpool Tramway Department for the ensuing year show that it is expected that the tramways will yield a profit of £7500 after making all allowances for capital charges and other expenses. Top-deck covered cars have been found most advantageous, and the number of these cars is to be increased by four other old Marton cars being fitted with these top-deck covers at a cost of £95 each.

ACCORDING to the *Electric Railway Journal*, one of the inter-urban lines of the Oklahoma Railway is equipped with reinforced concrete centre poles with semi-ornamental pipe brackets. This is an experimental equipment of twenty poles erected late in 1910. These poles are of the hexagonal type, 30ft. high with 7in. tops and reinforced walls 3⅝in. thick. The manufacturing cost per pole was 34s.

CONSIDERABLE progress has recently been made with the works in connection with the increased dock accommodation which the North British Railway is providing for the Fifeshire coal trade at Methil. In what will be the basin proper of the new dock little remains to be done at the north tongue, which was almost completely destroyed by the last heavy gale. What is regarded as the most difficult and dangerous part of the work has, however, yet to be undertaken, viz., the erection of the west jetty, this being rendered uncertain and dangerous by the inrush of water from the sea. Granted a continuance of favourable weather, the contractors hope to have the dock opened by the end of the summer.

THE Governor-General of Australia recently referred to the need for action in regard to the defence scheme of Australia, particularly with reference to the construction of railways. He suggested that the Government should borrow the necessary money to begin work without loss of time, and should build the lines needed for transport of troops and munitions of war. Then the further development of the railway plans of the Government could be taken up. The suggestion of the Governor-General has not been received with any degree of enthusiasm, probably because the Commonwealth's loans at the present time are at a figure that in financial circles it is thought desirable to reduce rather than increase.

IN Java good progress is being made with the construction of the railway line Tjikampek-Cheribon, and surveys have been made with a view to extending the line from Cheribon across the island *viâ* Tjiledoek-Boemiayoe and Adjibarang to Kroja on the line Maos Djocdjacarta. Surveys have also been made of the country between Kadhipaten (the western terminus of the tramway Samarang-Cheribon-Kadhipaten) and Malangbong on the line Maos-Bandoeng, and various small branch tramway lines are in course of construction throughout the island. In Sumatra surveys have been completed and plans submitted to the Netherlands Government of the so-called South Sumatra Railway from Telok Betong to Palembang, with a branch line from Praboemoelih to the oil fields of Moera Enim.

A CAR fitted up for military use by the Mexican Government is illustrated in the *Railway Gazette*. It is made from an ordinary box car, the inside of which is lined with steel armour plate. Three of the end holes are for two machine guns and one rapid-fire gun. There are also eight windows at the top of the sides, which are used for ventilation when the car is not under fire. They are protected by steel shutters which are slid over them when the car is in the danger zone. Ladders are placed at both side doors, so arranged that they can be readily swung down as soon as the door is opened or lifted up into the car after it has been loaded. It may be mentioned that the ceiling is lined with metal, which provides protection from any attack made from vantage points above the car. Although this car would not be a protection against shells, it is of decided advantage where only musketry fire is concerned.

ACCORDING to the *Electrical Engineer*, a new electrically driven rope railway has been constructed up the Niesen, a mountain famous for the views it commands, and rising to a height of about 6000ft. above the lake of Thun. Starting from Mulinen, in the Kandertal, the line rises 5400ft. in two sections. The length of the rope is 3850 yards. The incline is 68 per cent. in parts of the upper section. The rails weigh 53 lb. per yard, and the gauge is 40in. The pulleys over which the rope passes are from 11 to 16 yards apart. There are two pairs of electric motors, one at the top of each section. One pair is of 86 horse-power, the other of 60 horse-power. The normal speed of the carriage is about 2½ miles per hour, and one having a gross weight of 9 tons can be stopped in 40in. The lower cable is about 13in. in diameter, and weighs 8·8 tons. The upper cable consists of crucible steel wire. Each carriage carries forty persons.

THE complete service of electric trains was brought into operation on June 1st on the Victoria and the Crystal Palace section of the London, Brighton and South Coast Railway Company. By this service the suburban travelling public have now at their disposal 97 down trains daily, instead of 72, and 113 up trains, instead of 82. In a few months' time electric trains will also be running between London Bridge and the Crystal Palace. Some criticism having been passed upon the steam train service from London Bridge, the company states that the service is quite adequate for present traffic, but that it is quite willing when the traffic justifies such an extension to increase the number of trains. According to the *Railway Times*, thirty trains were run to the Palace from London Bridge on Whit-Monday, the shortest time taken for the nine-mile journey being 18 minutes, and the longest 37 minutes. The line to the Palace is a continuous upgrade of about 1 in 200, and it is urged that on normal days the time occupied—from 14 to 28 minutes—is not excessive.

NOTES AND MEMORANDA.

A NEW arc lamp giving a white light has been shown before the French Academy of Sciences by M. E. ROUX. According to the *Electrical Review*, the electrodes are tungsten for the positive and mercury for the negative; the arc burns in an atmosphere of inert gas or *in vacuo*, with a length of about 5 mm. The lamp consumes 0.45 watt per candle-power with a potential difference of 13 volts.

AT the Desert mill of the Tonopah Mining Company, a lathe is used for cutting zinc shavings, the unusual feature of which is that shavings are cut simultaneously on each side of the mandril. The two cutting tools are fed against the zinc by a screw feed. The screw feeds, one for each of the cutting tools, are operated by pawls, driven by excentrics that engage ratchet wheels on the screw feed axles. In this manner the high speed of the driving shaft is stepped down. The screws make 3·5 revolutions per minute, and are cut with threads so spaced that a forward travel of 0.58in. per minute is secured.

OLD wire rope is used in certain French mines for reinforcing old timbers, especially the cap pieces of sets. The old rope is stretched longitudinally around the timber, the ends being held fast between the roof and the top of the cap piece so they cannot slip. When a timber starts to bend under the weight of the roof, part of the tension is taken up by the wire cable, enabling a miner to put in additional supports before a fall occurs. The ends of the cap pieces are tapered and grooved deep enough to receive the rope and prevent any part of it projecting beyond the bearing ends of the timber pieces.

FOR extinguishing oil fires where water is both ineffective and dangerous, frothy liquids have been recommended. In a late test, near Hamburg, a mixture of one quart each of caustic soda and alum solutions yielded 15 quarts of a yellowish-white foam, having a density of 0.14, and this could be sucked up and distributed like water by a hose. A basement of 30 square feet, filled with benzine to 20in., was fired, and was extinguished in 78 seconds with 18 gallons of the frothy mixture, and a burning benzine tank, 6ft. in diameter and 9ft. high, was extinguished in 13 seconds. The benzine was little affected, burning as usual after removal of the froth.

IN a paper presented at the Detroit Convention of the American Brass Founders dealing with magnesium as a deoxidising agent in aluminium alloys it was pointed out that in making alloys it is a common experience to find at the first melting a metal which has been added will not be thoroughly incorporated with the alloy, and it is only after the second melting that the different ingredients blend together thoroughly. Then, too, the addition of a strange metal to a combination does not seem to form a homogeneous alloy at first, but if the main body of the metal already contains some of the metal to be added the blending seems to take place more rapidly and more uniformly.

ELECTRICALLY operated rock drills are used on a rock-drilling scow employed in the harbour of Trieste. According to the *Contract Record*, power is supplied to each drill by an electric motor, which is geared to a crank shaft. This effects the compression of a helical spring once in every revolution by means of a connecting-rod. The energy thus stored, when suddenly released, causes the downward blow. The average number of blows per minute is 380, and the stroke 2¾in. The holes can be driven at angles up to 15 deg. from the vertical, and the drill-rods can be fed down so as to give holes 6.5ft. deep and 3.2in. in diameter. These are driven in moderately hard limestone at the rate of 3¼ft. per hour.

GROUT instead of bituminous filler for brick pavements is recommended by Mr. Samuel Whinery, consulting engineer, in his preliminary report to the Commission on City Expenditures, Chicago. It is pointed out that the advantage of the bituminous filler lies in the fact that the streets may be thrown open to travel as soon as the filler cools and hardens, which will be well within twenty-four hours. If the grout filling is used, the street must be closed until the cement sets hard enough to withstand the travel—from four to seven days. Notwithstanding this, the grout filler, in Mr. Whinery's opinion, is so superior and so increases the useful life of the pavement that it should be used, except in the case of busy streets, where closing of traffic would work a hardship.

A PROCESS for the extraction of vanadium from chrome ores has been patented in France. Chrome ores usually contain a quite noticeable amount of vanadium which has not been recovered in metallurgical processes hitherto in vogue. Such ores are used chiefly in the manufacture of alkaline chromates and bi-chromates. In this operation the vanadium is transformed into an alkaline vanadate. To separate the metal, the solution is rendered ammoniacal; a manganese salt, either the chloride or sulphate, is added, which precipitates the vanadium in the condition of manganese vanadate. In the electric furnace, the manganese salt may be used directly in the formation of vanadium alloys, since at the temperature of such a furnace the manganese is completely volatilised.

THE engineer to the city of Philadelphia, Mr. Francis Head, records, in the *Engineering News*, some tests made on engine and turbine driven centrifugal pumps. There were eight sets of pumps, seven driven by compound engines of about 480 horse-power, and one De Laval steam turbine of about 500 horse-power. The head pumped against was about 44ft., but varied with the tide. The engine units ran at 177 revolutions, and the turbine pump at 742 revolutions per minute. The steam per water horse-power used by the turbine was 18.2 per cent. less than for the best three of the engine sets. Against this some allowance must be made owing to the steam for the turbine being superheated 53 deg. The vacuum was also better for the turbine. In daily practice Mr. Head states that the turbine pump takes less steam for a given amount of work done, and also requires less oil, attention, and maintenance. The actual steam consumption of the turbine per water horse-power on test was 18.96 lb. Owing to the low head, ram pumps would not be at their best, but under suitable conditions reciprocating pumps would improve on this performance. For low lifts centrifugal pumps are generally better than ram pumps, and for these the turbine-driven pump would seem to possess advantages.

THE vagaries of taps when used on brasswork, states the *American Machinist*, are often difficult to account for; but the combination sometimes of toughness with brittleness, or even "stickiness," in the metal may be noted. In the latter case the metal tends to flow or to be pressed to shape as well as to be cut. If the taps are too sharp, or have grooves too widely spaced, the tendency is to chatter. If they are not sharp enough—and the dividing line between these two states is hard to draw—excessive power is required to drive the tap, and heating of the work follows, with consequent deviation from standard size of the tapped holes. In fact, no sooner does the tap arrive at its best all-round capacity for cutting smoothly yet easily, and making a bright thread—the latter feature being partly due to a certain calendering action—than it commences to deteriorate rapidly. At the same time, it may feel and look quite sharp. The brass dust would appear to be pressed into the skin of the tap threads, and cause undue friction. The taps are still quite good for holes in wrought and cast iron and some mild steels, and this is worth remembering. For through holes, the life of the taps has been prolonged by making them in stepped form, each step having a full V-thread, and being equal in length to the article tapped. A recess, the depth of the thread, is made at the junction of each step; but the pitch is, of course, continuous for its full length. These taps may be used at distinctly higher speeds than with ordinary types, less heating being caused.

MISCELLANEA.

SO popular has electricity become in Strasburg, Alsace, as a means of motive power, that it is stated in a contemporary that not a single gas engine has been laid down in the town during the past ten years.

THE Consul at Bilbao reports that, according to Customs statistics, British makers only supplied 22 tons of electrical machinery and fittings out of a total of 514 tons imported during 1909. This is a too insignificant proportion of an important and increasing trade. Efforts are being made by British manufacturers to acquire a footing in the market.

AFTER a record dockyard repair in ten days, the armoured cruiser Inflexible, recently damaged in collision with the battleship Bellerophon, was floated out of dock at Portsmouth on Monday, June 12th. A good deal of the Inflexible's framework and many of her plates had to be renewed, and the completion of the work was facilitated by men being engaged upon it night and day.

POWER from the Roosevelt hydro-electric plant is used for pumping water for the Gila River Indian Reservation and for industrial purposes at Phœnix, the latter over a 65-mile 40,000-volt transmission. When the line was started up short circuits were caused by hawks and other large birds, which settled on the towers and touched the wires with their wings and bodies. The trouble was obviated by guards consisting of clips into which a number of pointed birch rods were driven. The birds would not settle on these points.

WE hear that the Prussian Minister of War has set apart a sum of £5000 for the purchase of military aeroplanes. The aeroplanes will be selected from the newest types that have given proof of qualities that render them specially suitable for reconnaissance work. An interesting feature is that only aeroplanes that are of German manufacture throughout (with the single exception of the motor) will be considered. In addition, the Ministry of War has already contributed a sum of £3000 for the establishment of a number of prizes, which makes a total of £8000 given by the military authorities as a direct encouragement to military aviation.

THE exceptionally fine weather conditions which have recently prevailed have enabled the contractors at the Rosyth naval base to make unexpectedly rapid progress, and there is now every expectation that the work will be finished well ahead of the schedule time. The number of men employed is 2000. Notwithstanding the rapid progress, many obstacles have been encountered, among which may be mentioned rock and running sand. Rock is being met with in large quantity in the western cofferdam. This is a great boon to the contractors, for, while the cost of its excavation is heavier than that of *débris*, it far more than repays its price of removal, as it can be used for innumerable purposes for which the contractors would have to buy rock. The work of reclaiming those parts of the foreshore which are to be the sites of the permanent buildings is proceeding rapidly, and it is expected that the work of constructing the buildings for which the present contractors are responsible will be commenced before the good weather has passed.

ONE of the features of American city life is the increasing recognition of the importance of guarding against the spread of contagious diseases. In the west one of the latest indications of the awakening to such matters is the increased number of sanitary drinking fountains in which pollution by germs from the lips of users is prevented by the flow of a constant stream of water over the surface of the upturned nozzles from which the men drink. At the International Smeltery at Tooele, Utah, somewhat similar drinking fountains are provided. These work on the same principle as the more elaborate ones in the cities, but cost a mere trifle. An elbow is attached to a nipple from a water pipe, and a funnel-topped drain pipe is provided below to catch the water that overflows. This elbow is screwed on securely and points upward, consequently the water as it discharges washes the sides of the elbow, and prevents the germs from adhering to it. Sufficient head of water is provided so that the jet rises about ⅜in. above the elbow before it falls back.

ON Thursday, June 8th, the Hon. C. A. Parsons delivered the Rede lecture to a large audience at Cambridge, when he took for his subject steam turbines. He said about £24,000 was spent on the investigation of the problem of marine propulsion by turbines before an order was received. The first turbine was made by Hero, of Alexandria, 2000 years ago. In the turbine vessel there was nothing of the disagreeable sensation of the racing of the engines whenever the screw came out of the water in a rough sea. The lecturer produced the pinion of the Vespasian, which had covered 20,000 miles and carried 90,000 tons of coal from Newcastle to Rotterdam in all weathers. It was removed from the vessel a month ago, and showed no signs of wear. Concluding, the lecturer ventured to predict that the use of the land and marine turbine will be steadily increased, and that the improvements that are being made to still further improve its economy will for a long time enable it to maintain its premier position as a prime mover.

AN important test of coaling at sea is shortly to be made with the new naval collier Vestal in connection with which test the United States Navy Department has ordered the employment of the battleship Virginia. This device of coaling at sea is of the Lidgerwood type, and it is required that the delivery of coal from the collier to the battleship shall be at a rate of at least 60 tons per hour for not less than eight consecutive hours, the speed of both ships being in the neighbourhood of eight or nine knots, and the collier towing the battleship. Some of the naval officers do not believe it is advantageous to undertake coaling at sea; at least with any attempt to effect a transfer of fuel while both collier and receiving vessel are under way. It is pointed out that this will require a special gear in the way of winches and other apparatus, and that in time of war, with the employment of merchant vessels as colliers, there will probably be a lack of such mechanism. At all events, some of the naval officers believe the coal could be more easily delivered from the side of a ship which suspends cruising for that operation. With the fleet proceeding at a speed of from 12 to 13 knots, which is now the cruising rate of the fleet, there will have to be in any event an appreciable reduction of speed to accomplish coaling at sea under the conditions which are contemplated in the forthcoming test.

THE Engineering Standards Committee has issued their report on British standard threads, nuts, and bolt heads for use in automobile construction. There has been, and still is, a great want of interchangeability in the smaller component parts of automobiles, and the adoption of the recommendations of the Engineering Standards Committee should be of material benefit to the industry at large, as the matter affects both user and manufacturer. The committee has decided to recommend the use of the British standard fine threads, but has found it desirable to alter the pitch of the ¼in. size from 25 to 26 threads per inch, and to introduce a new standard size of 7/32in. with 26 threads per inch. While recommending these threads for general use, the committee anticipates that there will be cases in which a special thread may be required, and here it has recommended the adoption of the Whitworth form, with a uniform pitch of 16 threads per inch irrespective of the diameter. With regard to the standard nuts and bolt heads, the British standard widths across the flats have been adhered to, but in order to save weight and space they are applied to a larger size of bolt. For example, the width across the flats of the nut for a ⅝in. bolt is that of the nut for the ordinary ¹¹⁄₁₆in. size, so that a considerable saving in weight and space is effected.

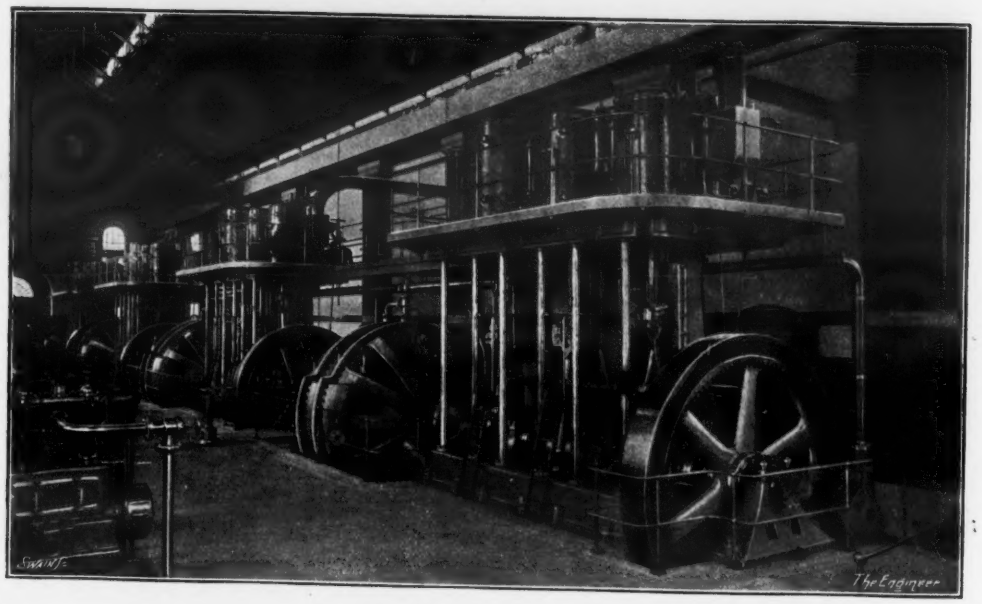
NEW PUMPING STATION AT WALTON-ON-THAMES

J. W. RESTLER, M. INST. C.E., LONDON, ENGINEER

(For description see page 616)

THE BOILER HOUSE

STEAM DYNAMOS AND ONE OF THE MAIN PUMPING ENGINES



THE MAIN PUMPING ENGINES

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Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Monday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other Letters to be addressed to the Editor of THE ENGINEER.

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PUBLISHER'S NOTICES.

*** *Next week* THE ENGINEER *will be published on* WEDNESDAY, *instead of* FRIDAY, *on account of the Coronation. New Advertisements should reach the Office before Five o'clock on Tuesday afternoon; alterations to Standing Advertisements cannot be made after Ten o'clock on Monday morning.*

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

DEATH.

On June 10th, at his residence, The Grange, Coventry, suddenly, Mr. W. H. HERBERT, Director of Alfred Herbert, Limited, Coventry.

MEETINGS NEXT WEEK.

(*See "Forthcoming Engagements" page* 630.)

THE ENGINEER.

JUNE 16, 1911.

An International Steel Trade Agreement.

THE question of the establishment of an agreement in the international steel trade will scarcely have been advanced—at all events, from the British point of view—either by the statements made by American steel interests before the Committee of the House of Representatives who are inquiring at Washington into the working of the American Steel Trust or the United States Steel Corporation, or by the events which immediately preceded the beginning of the investigation. As is generally known, the inquiry has followed those which have already taken place with regard to trusts for oil, tobacco, &c., in the United States. It is well known that, with the exception of the smaller firms, the Steel Trust, and the other large iron and steel undertakings which are independent of the Trust, have worked in harmony in respect of domestic prices of iron and steel for a long time past, it having been customary for conferences of representatives of the interested works to be occasionally held to discuss the commercial situation under the title of the American Iron and Steel Institute, which is a name bestowed upon the conferences by the Steel Trust as the originator of them. Apparently, the harmony, at least on the surface, has been disturbed, seeing that early in the fourth week in May it was announced that the Republic Iron and Steel Company, owing to the low prices charged for bars by some of the smaller firms, had decided to adopt a more aggressive sales policy, and had commenced by making a large reduction in bars. A few days later the Steel Trust, or its subsidiary companies, followed the example by lowering quotations for billets, bars, plates, and structural steel, &c., and there has consequently been a general fall in prices. The curious fact with relation to the price concessions is that they were made partly before the opening of the Government inquiry into the working of the Steel Trust, and partly simultaneously with the commencement of the investigation. The question, of course, arises as to whether any connection exists between the reduction in prices on the one hand, and the decision of the Federal Courts with regard to certain trusts and the Steel Trust inquiry on the other.

It is admitted that the object of the Steel Trust was to eliminate competition as far as possible, and the creation of the American Iron and Steel Institute represented a further step in this direction by the conclusion of friendly arrangements with the large outside or independent steel works, of which the Republic Iron and Steel Company is perhaps the most important. But the rupture between the Trust and this particular company, and the consequential decline of prices in general, show, for the present at all events, that there is no question of the exclusion of competition or any restriction in the freedom of trade. It is not our place to say definitely whether the reductions are intended to create an impression among the members of the Committee of the House of Representatives that keen rivalry exists in the domestic iron and steel market, or whether the concessions are of a genuine character; but having regard to the situation of the United States market, the balance of probability lies in the belief that the lower prices are dictated by the desire to give an impetus to business. It will, however, remain for the future to decide this somewhat delicate point. In the meantime the problem of concluding an international understanding between iron and steel producers in the United States, Great Britain, Germany, and Belgium will not have reached a nearer solution by the evidence given by Mr. Gary, chairman of the Steel Trust, before the Committee of the House of Representatives. What the Steel Corporation wants, the chairman is reported to have stated, is the establishment of some responsible official department of the Government to which the steel makers could look for the ultimate control of prices and operations. It is astonishing to find that the surrender of the system of competition in favour of Government control should be advocated from this quarter, although everyone is perfectly at liberty to draw his own conclusions as to the motives which have prompted the proposal at the present time.

The question of the ultimate control of the inland prices of iron and steel by the United States Government merely represents a suggestion, and need not disturb British iron and steelmakers in the absence of any definite scheme. But the mere fact that a proposal of the kind has been made from such an influential quarter should be sufficient to give further food for reflection on the part of British iron and steelmakers and exporters in respect of any project concerning an international agreement. The greater portion of the tonnage of iron and steel annually exported from the United States is controlled by the Steel Trust. As the cost of production in that country has largely advanced in recent years owing to higher wages and dearer raw materials, the promotion of the export trade has become more difficult, and is only possible on account of the higher prices realised in the domestic market. It therefore follows that if the home prices are reduced the export trade will become increasingly difficult unless external markets are forced at a loss, which could not be continued indefinitely. As prices have now been lowered in the United States, the circumstance represents a further argument against the conclusion by British iron and steel makers of any agreement which would afford additional facilities either to American or German firms to promote the export trade. It is, however, beyond question that the Germans will be unable to commit themselves in the matter at the conference which is to be held in Brussels early in July. The agreement which binds the constituents of the German Steel Syndicate, which controls a larger proportion of the native production than the Steel Trust does in the United States, will expire in twelve months from the present time, but no one could predict with any certainty that it will be renewed at the end of June, 1912. If the syndicate should collapse it is expected that inland prices would fall by at least 20s. per ton. Under the circumstances it would be exceedingly unwise for British iron and steel makers—even if it were possible to bring most of the exporting works into an agreement among themselves—to tie their hands in any way by an international agreement. Such arrangements as, for instance, the International Rail Syndicate and the former Tube syndicate, have been to the detriment of British interests, and any fresh understanding would eventually also operate against us either by reducing our share in the volume of trade or by our securing a lesser share in any increase than our two principal commercial rivals. If British firms hope successfully to meet the onslaught of these competitors, they will find it necessary to co-operate for the purpose by the creation of an organisation for the promotion of the export trade and the apportionment of the financial burdens resulting therefrom, and also for resisting foreign attacks in our home market.

The Calorimeter in the Power House.

THE same old question. It was asked in the days of James Watt. It is asked now. Given a ton of coal, how shall we get most steam out of it? We may reply in abstruse chemical language, or in the vernacular of the Midlands, or the stokehold. In neither case do we reach finality. There is no general answer. The search for one is as futile as that for perpetual motion or the philosopher's stone. Is there not a sore temptation to say that nothing more is to be learned by research or inquiry; all that can be known is known? This is not, however, the conclusion generally accepted. Someone always has something to say on the subject; and the something is, no doubt, occasionally useful in its way, even if that way means nothing more than the reiteration of some truth which is apt to be forgotten. The latest example is supplied by a paper read by Mr. Kershaw before the Association of Engineers in Charge, last December, Dr. Hele Shaw being in

the chair. The members are all supposed to be in charge of generating stations. They are also supposed to have the management of the most up-to-date steam machinery, working under conditions which render economy of maximum importance. Furthermore, this machinery is of very considerable power, and is worked under the most practical possible conditions. Mr. Kershaw is a chemist of some eminence, and he naturally kept pretty closely to the chemical aspect of the combustion of coal, and the production of steam. What Mr. Kershaw had to say was of the more value in that he knows not a little about steam and the steam engine, and understands the conditions under which steam is manufactured on the large scale. If his paper and the discussion which followed it do not add much to the world's knowledge, it perhaps is admissible to say that very little remains unknown.

Mr. Kershaw began by presenting his hearers with a rather novel diagram, which showed that of every hundred units of heat in the coal burned, twenty-four went away in the chimney gases, fifty-eight in the exhaust steam, fourteen in effective horse-power, two per cent. in frictional losses, and two per cent. in condensation in the steam pipes. These he gives as average figures. In other words, 1 lb. of quite dry coal of good quality will yield, when burned under perfect conditions, 14,500 thermal units, or, say, 11,194,000 foot-pounds, or 5.6 horse-power hours. "Therefore," says Mr. Kershaw, "the horse-power can be obtained from the heat stored in .18 lb. of coal, whereas the best results obtained in practice have been 2 lb. of coal per horse-power hour with marine engines, and 1.7 lb. with steam turbines, or from ten to twelve times the amount required by theory." This passage is misleading in several respects. In the first place it is thermodynamically impossible to get a horse-power in return for the combustion of .18 lb. of coal. In the second place numbers of marine engines do not require more than 1.5 lb. of coal per indicated horse-power per hour, and for mill work a guaranteed consumption not in excess of 10 lb. of superheated steam per indicated horse-power per hour is now-a-days quite usual for reciprocating engines. As 10 lb. is not an exceptional evaporation per pound of coal, a horse-power may be had for about half what Mr. Kershaw thinks. Steam practice is, after all not quite so bad as Mr. Kershaw told his hearers it was. In a sense this is a digression. No steam user estimates the value of a fuel in any terms save the number of pounds of steam which one pound of it will make. No one refers to horse-power when he is treating with the coal merchant, and this is really the best and simplest plan. The old practice was to guarantee such and such a coal consumption per indicated horse-power per hour. In the present day the engine guarantee is always based on water consumption; and so we come back to the direct questions—How shall we get the largest possible weight of steam in return for the combustion of one ton of coal? and, further, how shall we get the largest possible weight of steam for a sovereign? The two questions are almost inextricably entangled, because the boiler must be adapted to the kind of fuel to be burned. Under the title "boiler" must be included the furnace. Thus a boiler of the ordinary locomotive type is very unsuitable for burning dead slack in a generating station. Considering the questions we have just stated in various aspects, Mr. Kershaw concludes that "the fine slack or 'dant,' for which it is difficult at times to find a purchaser, will be found out and out the cheapest type of fuel, notwithstanding its 40 per cent. or so of ash." Here, again, we are met by a difficulty. In a colliery district the cost of carriage may be very small. What will it be when the station is situated, say, in London? This kind of fuel can only be properly burned on chain grates. The fires will bear little urging. The boiler power must be ample to deal with the peak of the load. It may be taken as an axiom that the cheaper the fuel the dearer will be the steam generating plant—a truth which we fear is too often overlooked.

The best portions of Mr. Kershaw's address were those devoted to the advocacy of chemical methods of obtaining the value of a coal. In many cases fuel supply contracts are framed upon what is known as the heat unit basis. The principle is quite correct, but it must be applied with much discrimination. A standard is adopted, and the purchaser pays in proportion as the coal delivered rises or falls above this standard as tested by the calorimeter. But it must be constantly kept in mind that it is not what is in the coal, but what can be got out of it that is of importance—a fact which Mr. Kershaw apparently ignores. Quite an inferior coal, as measured by the calorimeter, properly burned, may prove far better than a superior fuel fired in boilers that do not suit it. Like all other systems of arriving at values, calorimetry must be used intelligently. For our own part we regard it chiefly as a valuable means of maintaining coal at the standard guaranteed by the colliery owner. Indeed, Mr. Kershaw gives a most suggestive illustration of this. In one case "variations having occurred in the heating value as determined by the calorimeter, followed by *pro rata* deductions from the price paid for the fuel. These deductions caused the colliery owners to improve their plant for washing and screening the fuel, and the supplies are now once again up to the standard level as regards ash and heat units." Curiously enough, the Miners Eight Hours Act has imparted a special value to the calorimeter test; there is now more haste and less care used in the actual mining operations, and more shale and dirt are brought to the bank with the fuel than was the case two years ago. The larger portion of this dirt finds its way into the small coal or slack, and both in South Lancashire and in South Wales tests of the small coal from certain mines have shown that there has been a marked increase since the adoption of the Act. It must, however, be carefully kept in mind that too much value may easily be attached to any method of reducing the cost of steam that commends itself—possibly because it is new—to an engineer in charge. In the course of the discussion which followed the reading of the paper, Mr. Sugden cited a case in which he employed two men to fire boilers for pumping engines. He could always tell which man was at work by the quantity of water pumped, and "he found that one of these men was worth 20 tons a week more than the other." This is a cryptic utterance which must be taken for what it is worth. If the "tons" were water, it means very little, unless, indeed, the head was very high; if coal, a great deal too much.

It would obviously serve no useful purpose to say much here about the details of construction of boilers, feed heaters, or superheaters. There is an endless diversity of opinion and not many facts about these things. The interesting aspect of the whole question of steam generation just now is the growing popularity of not only chemical tests, but of scientific methods of ascertaining the influence and pecuniary value of the various factors which are concerned in the combustion of fuel and production of steam. The steam user is no longer satisfied with the knowledge that certain things occur either for good or for bad. He wants to know why they occur. What is particularly wanted now, however, is just that information which no men are better able to supply than engineers in charge. We are justified, we think, in assuming that they leave nothing undone to secure economy. Can they attach a pecuniary meaning to the word? Take, for example, the calorimeter test. A coal bill has been so much per month, let us say, in the past. What is it since the aid of the chemist was called in? A direct statement of this kind would do more to convert doubters than would any amount of argument, based on what "ought to be." Unfortunately, it has been up to the present just this type of information that it is most difficult to obtain. Why we do not know. This reticence does harm, because it lends force to the arguments of the older school of men who maintain that nothing the chemist can do will tell them more about the market value of a coal than they know already. No more potent means of effecting improvements can be found than the free interchange of information—a statement of the results of the experiences of men in responsible positions. It is, unfortunately, very difficult to overcome a reticence which in most cases seems to be inexplicable.

Commercial Training.

IT is, perhaps, not wholly a coincidence that we have in the last few days received copies of two lectures bearing upon the commercial training of engineers. Professor Ashley's admirable article on the subject, in our issue of April 28th, our own comments upon it, and the curious ideas expressed by at least one of our correspondents, have, no doubt, caused those who see eye to eye with us in this matter to offer us their support. We are very grateful to them. There is amongst many engineers a vague, rather undefinable feeling that "commerce is low," and that it is beneath the dignity, and outside the office, of an engineer to deal with financial questions. That feeling has to be overcome, and it will take years of hard work to overcome it. This paper has always maintained that the economic side of engineering is of no less importance than its scientific side, and it was one of the first, if not the first, to insist that commercial training should be included in the education of the engineer. That was many years ago, but it is only recently that opinion has begun to veer round to our side, and that the subject has received the attention it merits.

Of one of the two lectures to which we have referred we print a lengthy abstract on page 629. It is especially interesting for two reasons. In the first place, it was delivered by Mr. Frame Thomson, who has founded a fund to provide annual lecturers on such subjects as Commercial Law, Accountancy, Principles of Investment of Capital, and other kindred matters; and in the second place, these lectures are to be given to students of the Institution of Civil Engineers. The second fact is of prime importance, for if our greatest engineering institution lends its countenance to the movement we cannot doubt that before long it will receive the general recognition of all engineers. Mr. Frame Thomson's lecture was a founder's address, and in such discourses we look for generalities rather than detail, but it will well repay perusal. To survey his argument would be to repeat only what we have said over and over again in these columns, but we may be permitted to touch upon one or two passages which bear particularly on the opinion that trade is derogatory to the engineer. In one place Mr. Thomson says: "The object of these lectures would be hopelessly perverted if they tended to lower the ideals of which every engineer is proud. On the contrary, it is my earnest hope that one of the results will be to impress upon you that permanent commercial and financial success not only may, but must, be based on the same principles of reliability, efficiency, and security that you apply in your technical work. It is not true that either commerce or finance are disreputable either in their objects or their methods. . . . To have a sufficient and intelligent understanding of the principles and practice underlying their (the commercial men's) operations, so that where our work is precedent, parallel or supplementary to theirs, we may adjust it to produce the greatest combined efficiency, is no discredit to an engineer. On the contrary, the absence of such working knowledge prevents him from pulling his share of the load, and imposes needless difficulties and risks upon the other units of the team." This metaphor is very apt. The engineer, without any commercial instinct or knowledge, is unable to assist his financial partners by advice on technical questions, and he may, by adopting processes or methods without due consideration of their financial aspects, lay an enormous burden on the shoulders of the commercial side of business. It is not sufficient to assert that the commercial side should study the monetary aspect and say thus far and no farther to the scientist. If the latter is wholly without commercial knowledge, he will deem the action of the former short-sighted or blind, and become discontented because his pet schemes are not adopted. He must at least have such knowledge that he is able to appreciate the motives which direct the actions of the financial department. We take another passage:—"The perfection of engineering detail falls short of your whole duty if it is not accompanied by a judgment and imagination capable of appreciating the non-technical conditions which in the end control and limit its scope in each case." For non-technical we may put "market," and the paragraph means that the engineer who produces, without any consideration of the profit to be gained by his production, fails in his whole duty. He is engaged, whatever his position in a business firm may be, to make money, and however brilliant his inventions may be they are valueless if they do not work to that end. If an engineer engaged on the spectrum analysis of the exhaust from a gas engine for the specific purposes of improving combustion allowed himself to be deflected from that research to inquire into the occurrence of similar spectra in the atmosphere of Uranus, his employers would very properly discharge him. In the same way he is not justified in pursuing any course of research for which he cannot see some ultimate commercial good to his employers, and he falls short of his whole duty if he does so. The pursuit of science is for the scientist; the pursuit of money for the engineer. In the one case science is a goddess, in the other a hand maiden. The former is full of the greater delights, but it is not business. Business, engineering business, is the harnessing of science after the other man has caught her. We should find much to comment

upon in other parts of Mr. Frame Thomson's address, but we turn now, since diversity of evidence enforces argument, to some views expressed by Mr. G. A. Touche after the reading of the lecture. Mr. Touche, we may be forgiven for reminding our readers, is an eminent accountant. "I observe," he said, "the expression that commercial knowledge 'is no discredit to the engineer.' I would be inclined to go further and say that the absence of commercial knowledge is a discredit to the engineer, and that without it his work would probably be as sterile as that of the pyramid builders. I think the author feels that too, and recognises that commercial knowledge is essential to the engineer, but he probably feels it to be such a new proposition here that he must introduce it with great gentleness and delicacy." And again: "It is very desirable, in the interest of civil engineers, that you should wipe away the tradition that you, as civil engineers, are not greatly concerned with questions of commerce and profit." And finally: "Engineering and commerce are like husband and wife—they ought not to be divorced. The elements of engineering—the element of permanency, the element of efficiency, the element of safety, which I believe is the underlying element in all engineering—are essentially commercial elements. Therefore I would venture to say that the commercial aspects of engineering should never, under any circumstances, be forgotten." Readers who disagree with Mr. Touche may dismiss these sentences with the remark that they are merely the dicta of a man who is not an engineer, and is unable to appreciate the feelings of engineers. Let us assure them that they will be wrong in doing so. Mr. Touche may not be an engineer, but he expresses very accurately and forcibly an opinion that has long been held by many engineers, and is rapidly gaining the adherence of the remainder. It is not improbable that in a very few years time we shall look back to this view that commerce is derogatory to the engineer with unqualified wonder.

We have left ourselves no space to refer in detail to the second lecture mentioned in our first paragraph, and must content ourselves with saying that it was delivered by Mr. Frank H. Taylor, director and general manager of Linotype and Machinery, Limited, at Cambridge University, on May 15th. Its title was the "Need of Educated Men in Industrial Affairs," and it was natually wider in its scope than Mr. Frame Thomson's lecture, but it leads in much the same direction, particularly as regards the point that we have been enforcing, that a knowledge of commerce is not derogatory. Thus Mr. Taylor said: "A student who is from necessity or otherwise training for business in your University should stand among his mates with his head just as high as if he were working towards the Law or the Ministry, and should not be pitied and patronised." When it is remembered that the Linotype Company is not only a business but an engineering firm, the weight of Mr. Taylor's observation will be appreciated. We have endeavoured to show by abstracts from these two lectures that the engineer should feel no shame in considering the business side of his profession. The only argument against his studying business that is worthy of serious consideration is that it is unnecessary for him to load himself with matters that can be better attended to by the pure business man. Fuller treatment of it we must reserve for another occasion.

LITERATURE.

The Design and Construction of Ships. Vol. II. By Professor J. Harvard Biles, LL.D., D.Sc.

THREE years ago there appeared from the pen of Professor Biles the first volume of his work on "The Design and Construction of Ships." That volume dealt with what may be called the geometrical and mathematical calculations of form, such as displacement, centre of buoyancy, metacentre, coefficients of form, and also with calculations of stress and strain on the structure. A second volume, which deals more with the actual genesis of form to suit certain specific requirements, has now appeared. Its four sub-divisions are stability, resistance, propulsion, and oscillation—that is to say, rolling and pitching—of ships. Stability, in the first volume, was treated in the limited sense of stability in the initial condition; the new volume extends its range to include all phases of stability for all angles of heel.

In the preface to the first volume the author says:—"This book cannot possibly lay any large claim to originality. The greater part is necessarily the work of others who went before, or are now working for the advancement of the science of naval architecture. Very little attempt is made to acknowledge the sources of such help." In the preface to the second volume he says:—"The work on resistance, and propulsion, cannot fail to be largely an adaptation of the published work of those who have been fortunate enough to have the use of experimental tanks, from which alone such results can be obtained. Some of the adaptations have been made by following the original closely, rather than by making changes of doubtful advantage to the student."

It is therefore from this standpoint that one must view the book. It is frankly stated to be more or less a compilation of the work done by others, and as such it presents the complex subjects it deals with in a compact form for the use of students, for whom it is primarily intended. One would have liked to feel more strongly the personal note of the author on some of the debatable points discussed. He is often content simply to quote, voluminously it is true, but without passing any opinion as to the truth or error of the theories put forward.

The two parts of this volume which deal with resistance and propulsion are largely discounted by the very recent appearance of Mr. D. W. Taylor's book on "Speed and Power of Ships," which not only treats of the same subject but is the product of Mr. Taylor's own labours at Washington, and is also an exhaustive and up-to-date analysis of the subject in all its aspects. It will be seen that the previously published work of Mr. Taylor has been largely drawn upon by Professor Biles.

Chapters I. to IV. deal wholly with the geometry and mathematics necessary to determine isovols, isoclines, &c., for any specific form, and it is only in Chapter V. that the Professor comes to the practical methods of ascertaining stability qualities. He clears the way by saying: "The work of obtaining a complete set of isovols and isoclines is laborious, and it is not necessary for ordinary cases of vessels, where the stability is only required to be known for a small number of special conditions, and for a limited range of inclinations." Here the practical methods at present in general use are very clearly and concisely set down. Barnes' method of polar integration, the integrator method, and Tchebycheff's method, are all lucidly explained, and the mode of obtaining curves of G Z's from them clearly stated. The treatment of stability is quite exhaustive, and should prove of great value to those for whom it is intended. Professor Biles gives examples of the value of G M, in various conditions of lading, for different types of ship, but ends the discussion by saying: "The amount of stability required, for any particular vessel, can only be a matter of opinion based on experience"—which leaves the student pretty much where he was.

Part V. is devoted to Resistance. The Professor's opinion is that the subject of determining the form of least resistance for any set of conditions has so far proved too difficult for mathematical solution from *à priori* considerations. The only solution, which even in an approximate degree can be considered reliable, is the experimental one. Hence his attitude to the determination of ship's resistance is almost entirely that of the experimentalist. The investigations of Beaufoy are referred to, both the very early ones, which were conducted with a pendulum apparatus, and the later ones, which were done by towing the models with a falling weight. The author does not mention the fact that both of these methods still persist, notwithstanding the obvious difficulties, if not impossibilities, of obtaining accurate results. The late Mr. Frank Caws, of Sunderland, worked for many years at pendulum methods, and Herr Wellenkampf quite recently devised a method similar to Beaufoy's second apparatus, which was practically the same as Attwood's machine for deter mining the effect of gravity. The pendulum method for testing ship forms in water can scarcely be expected to succeed, for there is not time in one swing of the bob for the formation of the series of waves proper to the steady speed desired. Colonel Beaufoy's early attempts were attended with great trouble and disappointment. His latter method is always subject to the changing weight of the length of tow rope; but Wellenkampf has done all that is possible to make the method practical. The Froude method is undoubtedly best.

In Chapter VIII. the early work of the Froudes, father and son, is recapitulated, and the work of Coulomb noticed. The important feature of the latter's work was his experimental proof that surface friction resistance is independent of pressure, and therefore depth of immersion of a surface has no effect on frictional forces. This is obvious from the consideration that water, being practically incompressible, the weight of a given volume is always constant, and therefore the work done in giving the same motion is always the same. The formation of waves is dealt with in the orthodox manner, and is mathematically treated.

Attention is called to a peculiar feature of the formation of waves in canals. As the speed in feet per second of the fastest "long wave" which can possibly travel in a canal is $\sqrt{g\,d}$, where g equals 32.2, and d is the depth of the canal in feet, it follows that if a boat be dragged along the canal at a higher speed than this natural velocity, it will be unable to make a regular procession of waves at all. The discovery of this critical speed resulted in the introduction of light canal boats, known as "fly boats." The boat starts at a low velocity behind the wave, and at a given signal it is pulled up with a sudden jerk on to the top of the wave, where it moves with diminished resistance at a rate of from seven to nine miles per hour.

A description is given of the Experimental Tank of Messrs. John Brown and Co., Clydebank, and it is incidentally stated that this is the only electrically-driven tank in this country, all the others being rope-driven. Needless to say, this statement is quite inaccurate, and would have been inaccurate some years ago.

The author gives curves of resistance in terms of speed for different displacements of a model, and associates them to form a "surface of resistance," from which resistance at any speed or draught may be obtained. This is an elaboration more suited to academic study than to practical uses, for a cross curve in terms of draught or displacement can always be made from the resistance curves if required at any point.

Froude's "constant" method of standardising resistance results is explained, and much more of his published work included in this section, and his dictum which asserts that "the resistance of a form is determined solely by the curve of sectional areas, together with the extreme beam, and the surface water line of the fore body" is quoted. We may live to see that very general statement somewhat modified.

The author points out that the experiments he quotes show that prismatic coefficient is a better guide to resistance than block coefficient, which is, of course, quite true. The published results of experiments made by Professor Sadler, of Michigan University, to determine the effect produced by changing form of water line, while its coefficient is unchanged, and for constant block but changing prismatic coefficient, are given *in extenso*. Plottings of E.H.P. curves in terms of displacement for speeds varying between 15 and 36 knots, for twelve models, each at two draughts, as deduced from tank experiments, are also given.

A short chapter is devoted to the relation which subsists, in different types of vessels, between E.H.P. and I.H.P., and to the causes of the differences between these powers. Figures are given for this proportion in specific types, but the author appears to be very sanguine in some of them. For destroyers, with twin screws, and for liners, or full cargo steamers with single screws, he would expect .6 to .65 as the proportion. It is not stated definitely whether the E.H.P. of the twin-screw destroyer includes excrescences, but in any case few designers would, we think, care to base an estimate of power, in either case, upon so generous an anticipation of efficiency.

The influence of depth of water upon speed, as demonstrated by the published work of Captain Rasmussin, Major Rota, Mr. A. Denny, Mr. Yarrow, and others, is discussed, but here, too, as in the section on resistance, we have practically a repetition of the information collated in D. W. Taylor's recent book. The author adds curves of actual shaft horse-power in terms of speed, as obtained from trials of a destroyer 270ft. long, 26ft. broad, 8ft. 2in. mean draught, and 836 tons displacement. This vessel was tested upon the measured mile at the Maplins, where the depth of water is only about 7.5 fathoms, and at Skelmorlie, where it is 40 fathoms. The curves of S.H.P., torque, and revolutions per minute, are all fair for the Skelmorlie trials, but on that of the Maplins a hump appears on each of them at about 22 knots, which it should be noted is the critical speed for 7.5 fathoms as given by the formula $V = \sqrt{g\,d}$ in feet second units. Professor Biles founds on the information from Sir Philip Watt's contribution to the T.I.N.A., 1909, and makes the statement in other parts of his book, that the hump on the resistance curve always appears at this critical speed $V = \sqrt{g\,d}$, that is the speed of the wave of translation. This idea is now exploded—as pointed out by Mr. D. W. Taylor on the same subject—for all depths of water greater than .2 of the length, where the speed of the wave of translation becomes rapidly greater than the speed at which maximum increase of resistance occurs.

Professor Biles also deduces from these curves that the depth to be avoided, *i.e.*, that at which the violent increase of resistance occurs, is given by the formula

$$\text{Depth in feet} = \frac{(\text{speed in knots})^2}{10}.$$

This formula, taken in conjunction with the general formula for ordinary ships at ordinary speeds given by Major Rota, and confirmed by tank experiments at Washington, for the minimum depth of water necessary, if there is to be no increase of resistance, is valuable. Major Rota's formula is—

$$\text{Depth of water in feet} = 10 \times \text{draught in feet} \times \frac{V}{\sqrt{L}}.$$

It should, of course, be remembered that at speeds somewhat higher than these there is an actual reduction of resistance.

Dr. Froude's explanation of this peculiar phenomenon is divided into three principal elements:—

(1) As the water shallows, the stream lines become more and more two-dimensional in character, instead of three-dimensional. This tends to accentuate the stream-line variations of speed and pressure, and hence increases the resistance.

(2) The intensification of the stream-line variation of speed which increases the eddy making.

(3) The resistance due to wave making. This depends upon the relation between the speed of the boat and that of a wave of translation for the same depth of the channel.

Part VI. of the book is upon propulsion. The author devotes a large part of it to the theory and mathematics of the three types of propeller, screw, paddle, and jet, and to their mechanical efficiencies. He includes in it portions of a recent contribution to the literature of the subject by Professor J. B. Henderson, of the R.N. College, Greenwich, without, however, expressing any opinion upon its merits or demerits. This paper deals with the action of a screw propeller, as that of a moving sink and source combination, and deduces therefrom that the acceleration of the fluid ahead of the screw does not contribute to the thrust. Naturally a great many students of the problem are entirely at issue with this conclusion, including Mr. R. E. Froude. In the chapters on the practical application of experimental model screw results, the information given is strictly orthodox, and largely derived from Froude's classical pronouncements on the subject. Chapter XXII. frankly reproduces the body of D. W. Taylor's paper on the same subject.

Mr. Taylor's experiments and investigations in connection with the causes and cures of cavitation are freely drawn upon as far as they were available, and the early experiences with the Daring and Turbinia are given. No new light appears to be shed on this most interesting feature of the screw propeller problem. There is a short chapter on the conduct of measured mile trials.

Part VII., which is the fourth section of this volume,

deals with the problem of rolling, pitching, and heaving of ships in still water and in a seaway, and describes the various mechanical appliances which have been used to obtain accurate records of these motions. Extinction diagrams in still water from such instruments are given, and methods of analysis explained.

The late Dr. Froude's work is, of course, very largely quoted in this connection, for he was perhaps the greatest investigator of these phenomena that the world has ever known. The value of bilge keels to prevent rolling, as predicted by Froude from model experiments, and corroborated by full-size experiments with H.M.SS. Greyhound and Perseus, are also quoted. Later and similar work carried out upon three ships of the Royal Sovereign class by Mr. R. E. Froude confirmed the opinion held, that beneficial results may be expected to follow upon fitting of bilge keels, where rolling is to be reduced to a minimum. Short descriptions are given of some of the mechanical methods which have been tried for the prevention of rolling, and which have been very much in evidence of late years. The early experiments of Sir Philip Watts, with water chambers fitted to the Inflexible, are sketched, but only the barest mention is made of the more recent work done, and at present being done, by Professor Flamm, who is fitting water chambers of U shape to large Atlantic liners with apparently very successful results.

Moving weight methods, such as are presented by Sir J. I. Thornycroft's apparatus, and M. Victor Cremieu's rolling weight contrivance, are described, and consideration is also given to Herr Schlick's gyrostatic apparatus for the same purpose. The Professor is, however, content to describe the various methods, and gives no indication of his opinion as to their suitability, or otherwise, in the rough and tumble of sea service. Of their effect in reducing rolling set up in still water, or in a regular series of uniform waves, there is, of course, no doubt; but that is not the sea condition. He concludes with a short chapter on pitching and dipping oscillations.

This volume is a valuable instalment to the mass of information which will finally be embodied in the whole work, and admirably fulfills the purpose for which it has been compiled. The author has gathered together the best results which have been obtainable from many workers, and the completed work will form a kind of encyclopædia of naval architecture in comparatively small bulk. Professor Biles has a keen eye to select what is of use to him, and, as a consequence, of use to his, and to other students of naval architecture for whom he is catering. Much of the information so laboriously co-ordinated would otherwise have been so scattered as to be practically lost in effect; this work makes a concrete whole of the many independent contributions. As the author says in his preface, the work of ship design is an elusive subject, and the kind of knowledge accumulated, and stored up in these volumes, increases rapidly. Additions to our knowledge produce changes of type, which make the wisdom of a few years ago the folly of to-day.

DOCKYARD NOTES.

THE armoured cruiser New Zealand will be launched at the Fairfield Yard on July 1st.

THE new Chilian Dreadnoughts appear to hang fire almost as much as the Argentine ships. The latest report concerning them is that they will be of 29,000 tons and carry twelve 14in. guns.

THE *Times* is responsible for the statement to the effect that the Terni Steel Works in Italy are unable to provide sufficient armour for all the four new Dreadnoughts, and that tenders will probably be invited from abroad.

THE injuries received by the Inflexible in her recent collision with the Bellerophon were found to be more serious than was at first supposed. In addition to about fourteen square feet of the starboard bow being forced inward, the framework in the same part of the ship was so injured that it had to be replaced. The repairs probably constitute a record for Portsmouth Dockyard. The work was done in shifts from 7 a.m. to 7 p.m. and from 7 p.m. to 7 a.m. next day.

REPLYING to a letter signed by six members of Parliament representing dockyard towns, asking that the London allowance for draughtsmen might be raised to £50 per annum, Sir C. I. Thomas, Permanent Secretary to the Board of Admiralty, says that he is directed by the Lords Commissioners to state that the matter is the subject of a petition from draughtsmen employed in the Royal Dockyards, which is now under their lordships' consideration, and that a further communication will be made as soon as a decision has been reached. The allowance was recently reduced from £40 to £25 per annum for fresh appointments.

THE French torpedo boats Tourbillon, Lancier, 90, 146, 147, 148. 189, 204, 223, 243, and the Libellule have all been struck off the effective list.

THE three new destroyers now being built by Yarrows for the British Navy have been named Lurcher, Firedrake, and Oak.

THE Ersatz Heimdal has been launched at the Vulkan Company's Hamburg yard, and named Friedrich der Grosse.

AT a meeting of the Wednesbury Town Council on June 12th the annual report of the Electricity Committee was submitted, and showed that there had been an increase of 92 consumers, and the sale of current had risen from 433.267 units to 634.356 units. In two years the sales had increased by 410,648 units. The net profit for the year was £583. and it was proposed to write £245 off the free wiring account and to allocate £300 to the relief of the rates. The Council authorised extensions of the electricity works and plant at a cost of £2250.

IMPROVED PLAIN GRINDING MACHINE.

IN order to obtain the extremely high results which are looked for in work produced on modern grinding machines the latter must possess several essential features, namely:—Rigidity in all parts; freedom from liability to distortion; and long and ample bearing surfaces. As to whether the work or the abrasive wheel should traverse is open to discussion. Considerations of space in most engineering shops will, however, only permit of the wheel head being traversed in the case of plain grinders working on long shafts. The head must in this case have a long bearing on the bed to prevent, as far as possible, local wear.

Although it would be almost impossible to combine these qualifications in a new machine without making considerable use of the experience of previous makers, there is obviously still room for improvements in details. The illustrations on this page and on page 625 show views of a plain grinder built by Greenwood and Batley, Limited, Leeds, in several sizes, and intended to meet all reasonable requirements both as regards handiness and accuracy. The photographs reproduced are taken from a 12in. by 72in. machine, of which the following are the chief dimensions:—Grinding wheel diameters, 18in. and 20in. = face, 1¾in. and 2¼in.; cross adjustment of slide, 9½in.; range of automatic feed, 0—.005in.; countershaft pulleys, 15in. by 6in.; revolutions per minute, 560; horse-power required, 15; number of work speeds, 10; number of wheel speeds, 3; number of back rests, 5; and floor space occupied, 13ft. 6in. by 5ft. 6in. It will be observed from the illustrations that the driving headstock is operated by a single pulley, which runs at a constant speed. The headstock—a view of the interior of which is given on page 625—provides ten changes by means of tumbler gearing, any one of which speeds can be obtained by the movement of a lever on the front of the headstock. In this headstock the intermediate gear wheel is carried in a swing frame, which is controlled by means of a worm and segment wheel, the whole being carried in a slide fastened to the box. In making a change of gears the intermediate spur wheel is wormed out of mesh with the nest gears by means of the handle shown. The correct speed for the work is then chosen from the index, and the handle is slid into position and locked. The action of winding the intermediate wheel into gear locks the whole of the swing frame solidly. To regulate the depth of mesh of the intermediate and nest wheels screw adjustment is provided. All the small gear wheels are of steel, accurately cut and hardened. There is nothing very striking about the loose headstock, which has hand wheel adjustment and a special clamp, a spring being provided inside the head to allow of the expansion of the work due to the heat engendered by grinding.

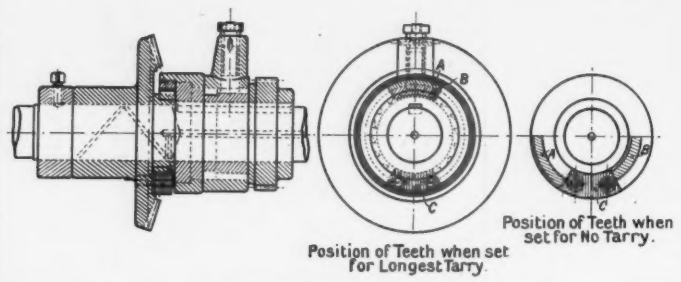


Fig. 1—TARRYING MECHANISM

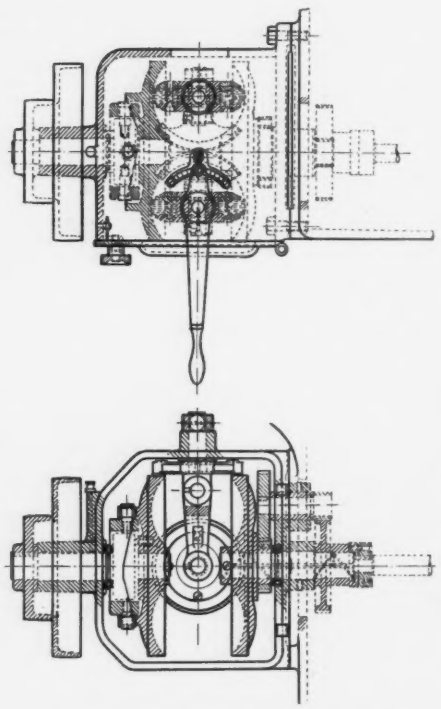


Fig. 2—FRICTIONAL CHANGE FEED GEAR

The grinding head is designed to ensure freedom from vibration under heavy duty. It has a carbon steel spindle hardened and ground and running in gun-metal self-aligning bearings with ample lubrication. Variety of speeds is provided for the abrasive wheel by fitting a step cone pulley on the countershaft. The wheel is well enclosed and the wheel slides are of ample surface. The proper degree of tension of the belt is maintained by an automatic belt-tightening device. The automatic cross feed is positive and is controlled from the hand wheel in front of the machine, the desired rate of feed being instantly obtained by the setting of a pawl on a ratchet wheel with a graduated scale. The feed acts at the points of reverse only, and not while the carriage is in the act of traversing, thus eliminating the tendency to form taper ends to the work. In addition to the automatic cross feed and quick hand feed, the machine is fitted with a fine hand micrometer feed, each graduation representing a reduction of .00025in. off the diameter of the object. In this manner frequent gauging of the work is rendered unnecessary.

A feature of importance in the production of accurate repetition work is a stop device fitted to the hand feed mechanism. One piece having been ground to the correct device, the stop is adjusted and the operator is then able to grind a number of articles to an exactly similar diameter, the only adjustment necessary being, of course, that due to wear of the wheel surface.

The traverse of the carriage is effected by means of a friction driving mechanism operated by the lever shown at the bottom left-hand side of the machine in the upper view on page 625. Sectional views of this friction gear are also given in Fig. 2. The operation of the gear will be readily followed from the drawings, and it will be understood that a very wide range of feeds is provided, according to the position of the two balanced friction wheels between the grooved discs. The gear is provided with ball thrust bearings.

The reverse is controlled by adjustable dogs in front of the machine, which are fitted with quick and fine hand micrometer adjustment, enabling the traverse to be set accurately when grinding up to a shoulder. To prevent damage to the carriage slides by water and grit these are protected by water-proof roller blinds. A feature of the traversing motion, which the makers claim to be of particular merit, is a tarrying device, which automatically provides a variable dwell of the carriage at each end of the traverse, whilst the work makes as much as one revolution when running at the slowest speed. A sectional drawing of this device is given in Fig. 1. It consists of a one-jawed clutch in two concentric parts A B, one outside the other. The outside section can be adjusted so that the distance between the driving faces can be regulated to give the desired length of dwell. The driving lug C is firmly secured to the bevel wheel, and it is driven in one direction by A, and in the other by B. Thus, by placing A and B in contact with its opposite faces, there is no tarry, whilst by placing them on the opposite diameter the longest tarry is given. It should be mentioned that the jaw clutch is fitted on the rack pinion shaft.

As will be seen from the end view of the machine on page 625, the table is arranged to swivel for grinding taper work, and can be easily clamped in position. Two graduated slides are provided to the end of the table, a pointer indicating the taper in "inches per foot," and in degrees. The steady rests are fitted with means for adjustment horizontally and vertically, and a centrifugal pump is provided for the cutting lubricant contained in the tank shown in the end view.

THE RACKING OR SKEWING OF OVERHEAD TRAVELLING CRANES.

By EDWARD G. FIEGEHEN, A.M.I. Mech. E.

THE tendency of an overhead travelling crane to take up a position out of square with its track rails when travelling is variously known as "racking," "skewing," or "cross-winding." The results of this defect are rapid wear of the wheel flanges and greatly increased tractive resistance. The forces at work, however, do not appear to be sufficient to cause actual derailment—at least, so far as the author is aware; but their effect upon the somewhat flimsy rail fastenings one occasionally meets with at least deserve attention.

The most frequent and obvious cause of skewing is to be found in the inequality in diameter of the two driving track wheels, due occasionally to careless workmanship in the first instance, but more frequently to subsequent unequal wear of the treads due to a difference in the hardness of the metal. The nature of the work performed and the location of the heavier lifts often causes greater wear to take place upon one side of a crane than upon the other, resulting in skewing.

The obvious precautions against such contingencies are:—Accuracy in the first place, cast steel wheels for normal work or wheels with hard steel tires for very heavy service and occasional re-turning when the inequality in diameter becomes a source of trouble. It is essential that the end carriages and axle-bearings of the driving wheels should be designed so as to facilitate the removal of the latter for re-turning without dismantling adjacent parts.

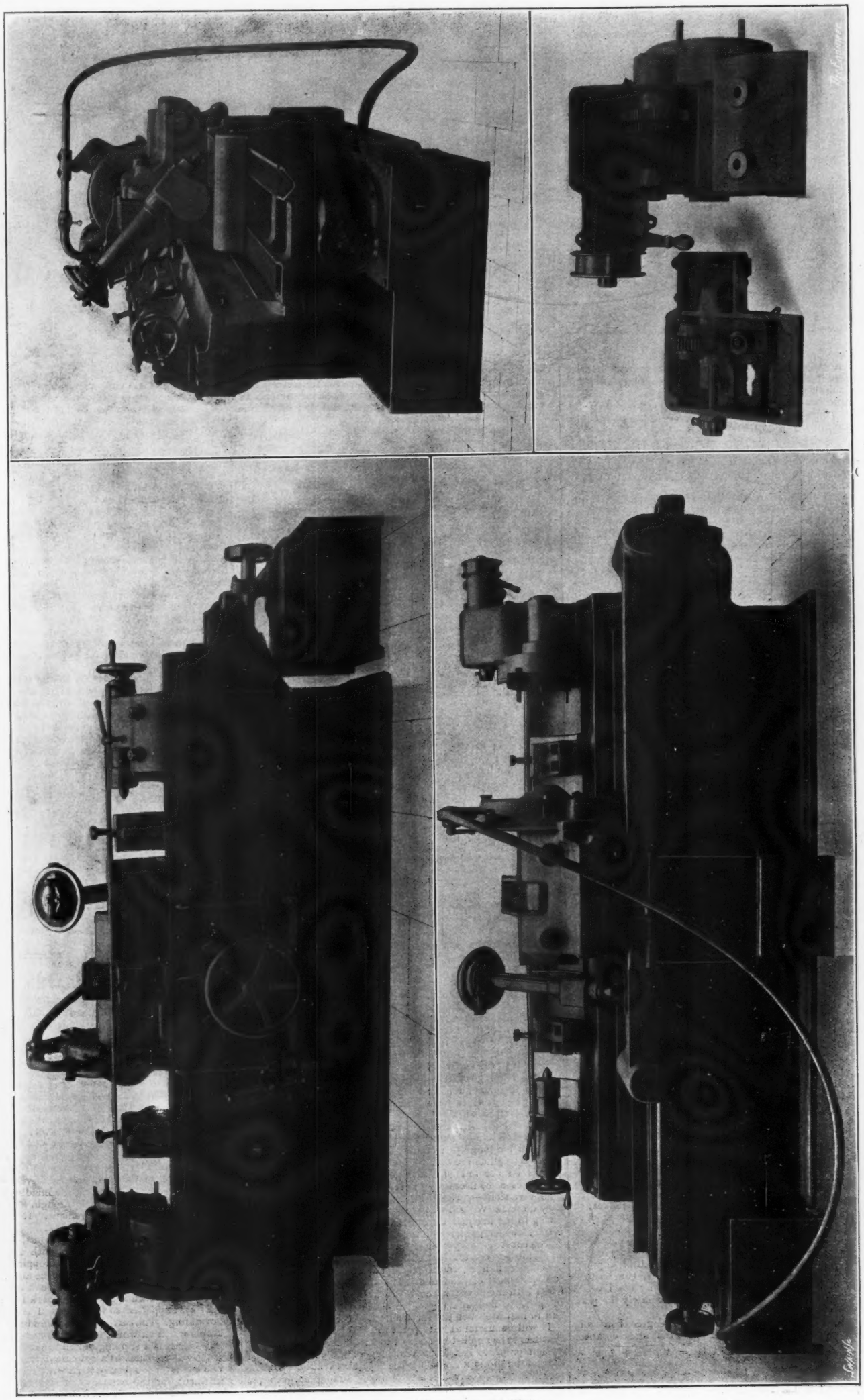
The effect of inequality in the diameter of the driving wheels is to cause the crane as a whole to travel in a curved path of large radius, and it is therefore merely the question of side clearance and wheel base that determines the point upon a straight track, where the further radiation of the crane is checked by the contact of the wheel flanges with the track rails. The further progress of the crane will be accomplished in this skewed position, accompanied by increased tractive resistance and abrasion of both flanges and rail. The same effect will be produced if any of the track-wheel axles are mounted out of square with the centre line of the end carriage to which they are fitted. Driving axles will usually be carefully aligned to ensure the correct meshing of the spur gears, but trailing axles do not always receive equal attention and thus become an unsuspected source of trouble.

A third cause of skewing, occurring chiefly when starting and stopping, is that due to the torsional flexibility of the transmission shafts, and occurs when heavy loads are transported, whilst the crab is close to one end carriage, thus putting unequal loads upon the end carriages. The effect produced is transient, and is not cumulative as in the previous cases, and perhaps too much importance has been attached to it in the past. Whilst there can be no question as to the superiority of the "central drive," as applied to longitudinal travelling motions, yet we hope to show that

PLAIN GRINDING MACHINE

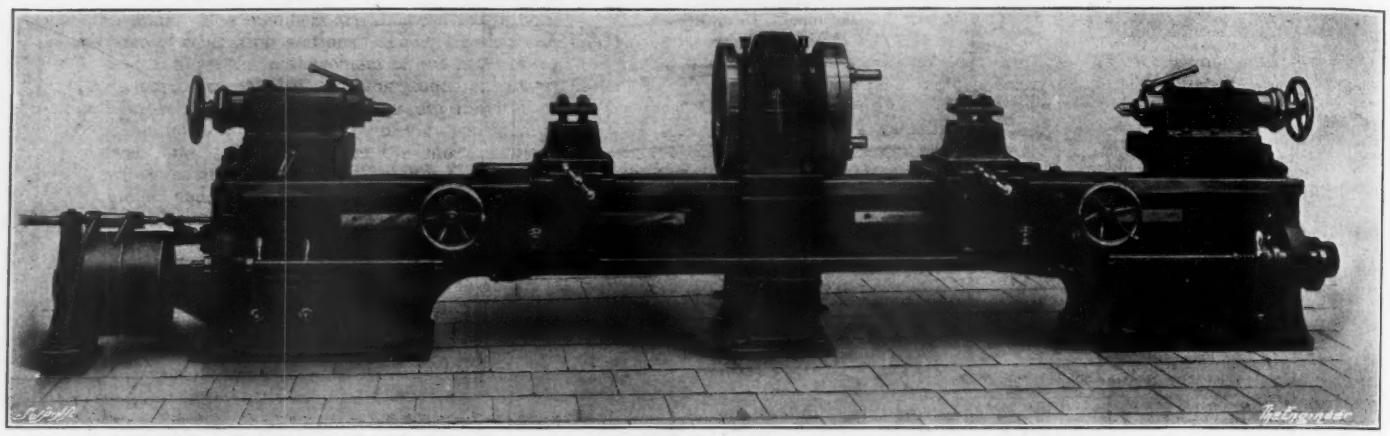
GREENWOOD AND BATLEY, LIMITED, LEEDS, ENGINEERS

(For description see page 624)



AXLE TURNING LATHE

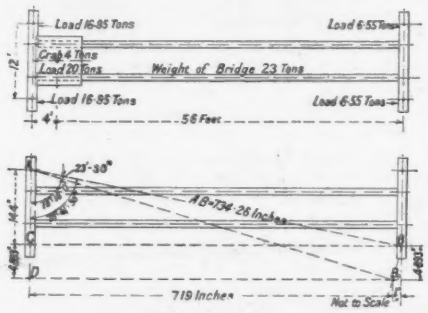
POLLOCK AND McNAB, BREDBURY, ENGINEERS



there is no need for the purchaser to become apprehensive of skewing if the power in a particular case is applied a few feet on one side of the actual centre of the span.

To illustrate this point, let us take the case of a 20-ton electric overhead crane built for 60ft. span, and shown diagrammatically in plan by Fig. 1. To take the worst conditions, assume the loaded crab traversed over within 4ft. of the left-hand gantry rail; assume further that the bridge of the crane weighs 23 tons, whilst the crab complete weighs, say, 4 tons. The wheel base of this crane would be 12ft., or thereabouts.

Now it is obvious that the limit of the power that can be transmitted to the track wheels at either end is reached when slipping commences between these and the rail, and we can base our calculations of shaft torsion upon this as the worst condition, although normally it will not be approached except possibly by the sudden application of a powerful foot



[Figs. 1 and 2

brake. The total load upon the left-hand driver under the conditions assumed is, therefore, $\frac{23}{4} + \frac{24 \times 56}{60 \times 2} = 16.95$ tons, and assuming adhesion at one-fifth of the wheel load we see that 3.4 tons applied horizontally will be needed to cause this wheel to slip upon the rail.

Similarly the load upon the right-hand driver is 6.55 tons, and its adhesion 1.31 tons. A crane of this size would have a cross shaft, say, 2¾in. diameter, and we may reasonably assume that the pinions at each end of this are 6in. diameter gearing into axle spur wheels, which we will further assume are equal in diameter to that of the driving track wheels, thus making the pitch line load upon the pinion at each end equal to the adhesion.

When slipping is about to occur we shall thus have a twisting moment of $3.4 \times 2240 \times 3 = 22{,}800$ inch-pounds upon the left-hand half of the cross shaft and $1.31 \times 2240 \times 3 = 8800$ inch-pounds upon the right-hand end.

Adopting the usual formula:—

$$\text{Twist (degrees)} = \frac{584 \times \text{torque (lb. in.)} \times \text{length (in.)}}{\text{G (coeff. of rigidity)} \times D^4 \text{ (in.)}}$$

We have twist (left-hand section)

$$= \frac{584 \times 22{,}800 \times 360}{13{,}000{,}000 \times 25.5} = 14.5 \text{ deg.}$$

Similarly, twist = 3.76 deg. for right-hand section, showing a difference of 10.75 deg. between the two ends. This angle upon the pitch circle of the pinion is subtended by an arc of $\frac{6 \times \pi \times 10.74}{360} = 0.562$in., which will, of course, represent the linear advance of one wheel tread beyond the other, so that when starting under maximum starting torque or skidding with the brake hard on, one end carriage (the left-hand one in the present instance) will lag about $\frac{9}{16}$in. behind the other, and this small amount will certainly not produce appreciable skewing; furthermore, provided that slipping does not actually occur at the track wheels, the natural elasticity of the shaft will automatically bring the lagging end carriage into line with the other immediately the peak load is passed.

It may be useful to investigate to what degree skewing is possible under normal conditions of wheel base and clearance.

Referring to Fig. 2, diagonal $AB = \sqrt{720^2 + 144^2} = \sqrt{539{,}136} = 734.26$ in.

Hence, $\sin BAC = \frac{720}{734.26} = 0.98058.$

Therefore, angle BAC = 78 deg. 41 min. 30 sec.

Again, $\sin B_1AD = \frac{719}{734.26} = 0.97921.$

Therefore, angle B_1AD = 78 deg. 18 min., the difference, viz., 23 min. 30 sec., being the angle of skewing permitted by the clearance (nominally ¾in. in the wheel treads and increased actually to 1in. by minor clearances) and wheel base (12ft.) adopted.

To find the linear lead CD permitted under the same conditions—

We have $AD = B_1A \cos 78 \text{ deg. } 18 \text{ min.}$
$= 734.26 \times 0.2027873$
$= 148.893.$
Deducting AC 144.0

$CD = 4.893$in.,

and thus one end carriage will have to gain upon the other to this extent before binding upon the track takes place.

To find the length of travel in which binding will take place due to unequal wheels, we have—

Gain of larger wheel per revolution = $\pi \times$ difference in diameter.

Therefore the crane must run, to allow the larger wheel to gain x inches, and assuming a difference between the diameters of the wheels (nominally D feet diameter) of δ inches, a distance of:—

$$= \frac{x}{\pi \times \delta} \times \pi \times D = \frac{x\,D}{\delta} \text{ feet.}$$

In the above case, to gain 4.89in. with, say, ⅛in. difference between wheels nominally 2ft. 6in. in diameter, the crane must travel

$$\frac{4.89 \times 2.5}{0.125} = 97.8\text{ft.},$$

assuming, of course, that the crane starts square with the track rails; beyond this distance the crane will continue to travel at an inclination of about 23½ minutes, or nearly half a degree, from its normal position.

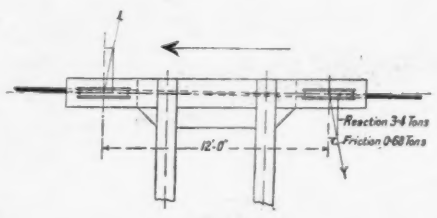


Fig. 3

A glance at the above formula will show that the distance covered before binding takes place, for a given error in the wheel diameters varies directly as their nominal diameter, and since the wear upon track wheels varies roughly in the same ratio, we can say that the tendency of cranes to skew upon their tracks, due to the wear of the wheels, is inversely proportional to the square of the diameters of the latter.

The foregoing remarks have necessarily been based upon the assumption of a perfect track—straight, level, and true to gauge—but it is hardly necessary to remark that such tracks, even when newly erected, are the exception rather than the rule. In the case of irregular and ill-supported tracks, such as are found upon outside gantries especially, and also for long span cranes, it is usual to abandon the attempt to guide the crane by the flanges of all four track wheels on account of the large side clearance that would in such cases be necessary in order to accommodate considerable variations—perhaps 1½in. or 2in.—in span, which, if they do not have such values when new, may easily develop owing to the unequal settlement of the supports, or, in the case of wooden gantries, to the warping of the timber.

The construction preferred in such cases is to make the wheels in one end carriage with, say, ¼in. clearance, and with substantial flanges, and to rely upon these alone to maintain the squareness of the crane. The opposite end carriage is fitted with much wider wheels to allow for possible variations in span, the flanges being added as an additional safeguard and to indicate when the variations are becoming too serious.

It will be useful at this point to consider briefly the force that has to be applied by the rail to the wheel flange in each case in order to resist the tendency of the crane to skew beyond the limit allowed by the clearances adopted. The restraint imposed involves a continuous sliding between the wheel tread and the rail in a transverse direction, and to accomplish this the adhesion between them has obviously to be overcome. We can say, therefore, that the rails exert forces at right angles upon the wheel flanges at the point of contact equal in each case to the adhesion.

In the case of the 20-ton crane under the conditions assumed we should have two forces, each of 3.4 tons acting upon the left-hand end carriage as a couple with an arm of 12ft. and tending to rotate the carriage with respect to the main girders as shown in Fig. 3. We have in addition the reaction of the rail due to the frictional resistance between itself and the wheel flange, and assuming again a frictional coefficient of ⅕ we get $\frac{3.4}{5} = 0.68$ tons as the value of this, and it is evident that its line of action is also horizontal.

Fig. 3 indicates the substantial gusset plates that are usually introduced at the junctions of girders and end carriages. The functions of these gussets are not always clearly understood. Obviously their presence cannot prevent skewing, the wheel flanges above keeping this within safe limits. Neither can their presence prevent the distortion introduced by the flexibility of the cross-shaft, which amounts, as we have seen, to less than 1in. in 60ft., and is easily accommodated by the flexibility of the girders in the horizontal plane. Further, it is clear that the rotational forces upon the end carriages can be adequately resisted by the double connection to the girders.

The functions of such gusset plates therefore appear to be:—

(1) To add lateral strength to the overhanging ends of the end carriage to enable them to resist the horizontal thrust of the rail.

(2) To add lateral rigidity to the girder connection, and thus greatly increase the stability of the bottom flanges. In cases where girders have to be dropped and attached to the inner vertical face of the end carriage such lateral stiffening is much needed.

(3) To provide an increased area in which attachment bolts can be placed so as to be accessible, and to avoid the local weakening that is unavoidable when such bolts are crowded within the limits of the flange angles of the girders.

(4) To increase the rigidity of the entire framework against racking forces tending to destroy its squareness. It may here be remarked that even if the girder connections were entirely devoid of rigidity—such as vertical pin joints—the parallelism of the carriages would not be destroyed by a considerable distortion of the framework, so that weakness at these points will not of itself conduce to racking. With unequal wheels, however, weak girder connections may easily permit one carriage to advance 4in. or 5in. beyond the other, and since this distortion takes place in alternate directions, it is only a matter of time before the connection bolts become loose in their holes; substantial gussets will constrain the bridge to skew as a whole, and not act as a parallel ruler.

AXLE LATHE.

THE chief features of the axle-shaft turning lathe, illustrated above, are the central driving head and the worm-driven aprons to which the tool slides are attached. The power is transmitted by means of a single pulley from the line shaft to an all-gear drive giving four spindle speeds. The advantage of this drive over the stepped-cone drive is that the belt velocity remains constant when turning on all diameters. The gearing is enclosed in a box formed, as will be seen, in the left foot of the machine. It is machine cut out of a special steel alloy, and runs in an oil bath. The variations of speed are geometrically progressive, and are altered by moving the two levers shown. These are interlocked, making it impossible to engage more than one pair of wheels simultaneously. The central driving head is securely held to the bed, and is driven by cut spur gears from a shaft which runs along the middle of the bed. It has a hole 10in. diameter bored through, and has a Clement's driver to allow of lateral movement. If necessary the head can be made movable along the bed.

There are two carriages and aprons, one right and one left hand, and the motions in both are identical. The whole of these are controlled by a dropping worm, which can be engaged and disengaged instantaneously. When engaged the aprons slide towards the middle of the bed. The worm drive has ball-thrust bearings, and all the wheels in the aprons are supported so that the feed shafts and wheels are not overhung. The carriage cross slides have raised V bearings of ample width on which strong tool rests are placed, and on the feed shaft is a slipping clutch to prevent damage by overloading. It also acts as a cut calculator.

The bed is of the box pattern with square lips and cotter adjustment for the carriage. The twist of the carriage is taken by a raised lip on the front shear, so that the thrust of the pinion on the rack exerts a straight pull with the minimum of torsion and steady feed. The loose headstocks are massive, and that on the left hand is made to wind out of line for the passage of axles through the central head. There are three feed motions of ⅛in., 1/16in., and 1/32in. per

revolution of the spindle, engaged by a lever placed at the right-hand end of the bed whilst the machine is in motion.

The machine is made in two sizes. The one illustrated has 12½in. centres; length of bed, 16ft.; between centres, 11ft. 6in.; breadth of bed on face, 1ft. 8½in.; spindle speeds, 16.9, 28.7, 46, and 78.4 revolutions per minute; and diameter of driving pulleys, 18in. by 6½in.

The machine has been built by the firm of Pollock and McNab, Limited, Bredbury, near Stockport.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

LOSS OF HEAD AT BENDS IN PIPES.

SIR,—In THE ENGINEER of May 26th there appeared an article on this subject by Mr. E. S. Bellasis. The author endeavours to summarise the work that has been done on bends, but I cannot think that this summary is either in accordance with the facts as found by the various investigators or helpful to those who wish to know how to estimate the resistance of bends in design.

I carried out a research at Birmingham University, of which the results were published in 1904. These were not complete, but certain conclusions then drawn were put into practice in pipes of various size with complete success.

(1) "The best curve is one whose radius is 2½ diameters." (This is in complete agreement with the elaborate experiments, extending over several years and made on large city mains in Detroit by Williams, Hubbell and Fenkell.)

(2) "The resistance offered by bends is of the same nature as that offered by straight pipes, and is proportional to the same power of the velocity."

Mr. Bellasis says a bend of 15 diameters is best; the experimental results of the authors he quotes do not show anything of the kind. Further, he expresses the resistance as

$$H_B = Z_b \cdot \frac{V^2}{2g}.$$

Again, the experimenters quoted do not agree with this. The head lost in a straight pipe does not vary exactly as the square of the velocity in all cases, and in several is markedly different.

The two conclusions stated above are of great value in design for the following reasons:—

(1) Special pipes for curves cost much more and are harder to lay than straight pipes. On so-called "easy" bends the number of specials is large. In turning through 90 deg. in wide streets it is possible, by using two one-eighth bends (of 45 deg. each) connected by a piece of straight, to reduce the number of specials to two, or, at most, four. This gives a main of actually less frictional resistance, and those who are acquainted with this class of work can soon figure out the saving found on a 90 deg. bend with, say, 30in. pipes.

(2) For all ordinary calculations, such as those carried out in waterworks and municipal offices, a formula such as

$$H_B = Z_b \cdot \frac{V^2}{2g}$$

is absolutely worthless, because when given any two of three quantities, "discharge," "gradient," and "diameter," it is hardly feasible to determine the third otherwise than by trial and error.

I put forward the following formula tentatively in 1904 (the values of the constant and of the index being subject to alteration on a more exhaustive investigation).

$$L = 12.85 \left(\frac{D}{2R}\right)^{.83} l,$$

where

L = Length of straight pipe that will offer the same resistance to flow as the extra resistance due to the bend.
D = Diameter of pipe.
R = Radius of centre line of bend.
l = Length of bend, measuring along centre line.

This formula was first applied in the design of a 36 diameter cast iron syphon in Hope-street, Birmingham, where bends of 2½ diameters were used with complete success, and where "easy" bends would have been impossible.

The particulars are as follows:—

There are six bends, each of about 40 deg., diameter 3ft., radius 7ft. 6in., and length 5ft. 3in. It is not correct to assume the resistance for 40 deg. to be a proportionate amount of that for 90 deg., but in the circumstances of this case—which it would take too long to discuss fully—it is a fairly good approximation to calculate for a total length of bend of

$$6 \times 5\text{ft. } 3\text{in.} = 31\text{ft. } 6\text{in.}$$

[The total length of the actual syphon, including bends and tangents, is 82ft.]

$$\text{Then } L = 12.85 \left(\frac{D}{2R}\right)^{.83} l$$
$$= 12.85\ (.2)^{.83}\ l$$
$$= 12{\cdot}85 \times 0.263\ l$$
$$= 3{\cdot}378 \times 31.5$$
$$= 106.4\text{ft.}$$

That is, the introduction of these six bends is equivalent, as regards resistance, to the addition of 106.4ft. of straight.

Therefore, in calculations on this syphon all that is necessary is to call the length

$$82.5 + 106\ 4$$
$$= 189\text{ft., say,}$$

instead of 82ft. 6in.

Thus, supposing a gradient of 1 in 100 is required to give the required discharge with this 36in. pipe, it is necessary to give the syphon a head of

$$\frac{1}{100} \text{ of } 189 = 1.89\text{ft.}$$

Similarly, in laying sewers and culverts, provision can be made for bends. I have laid out sewers with bends of this radius, but generally speaking a radius of 5 diameters is about the minimum. In setting the sight rails for a curve all that need be done is to calculate L by above formula, add this to length of the curve, and set the rails for a length of $(l + L)$ instead of l.

This effectually prevents silting and troubles like that.

I do not pretend that this formula is either elegant or even dead correct arithmetically. It is an empirical expression, which gives a close approximation to actual results in a form in which rapid calculations can be made by those in practice. After all, while it is very interesting to discuss this, that, and the other feature observed by different investigators, ordinary people are only puzzled by such articles, and led to believe that simple solutions of everyday problems are impossible. I offer the above formula as one that has been applied to pipes of all sizes up to 42in., with every indication of agreement with calculations, and I believe that no other formula has yet been put forward which offers either so correct or so ready a solution.

C. W. L. ALEXANDER.

University College, Cork, June 14th.

THE VALUE OF A VACUUM.

SIR,—The article on Vacuum in your last issue is of particular interest to marine engineers.

On shipboard there is a certain amount of exhaust steam from the auxiliaries always available, and as the only way in which its total heat can beneficially be utilised is by raising the temperature of the feed water, it follows that a definite relationship must be established between the hot-well temperature, the available exhaust steam, and the limit of temperature at which the feed pumps will work satisfactorily.

At present the average practice when independent feed pumps are employed is to heat the feed-water in a direct-contact heater with steam taken from the low-pressure casing of the main engines and to discharge all the auxiliary exhausts to the condenser.

Thus to reduce deliberately the power of the main engines by robbing them of steam in order to heat feed-water, and at the same time wilfully to discharge all the heat in the available exhaust steam overboard by way of the condenser, is, to put it mildly, very unfair to the shipowner.

In the class of boat in which independent feed pumps are fitted there is usually sufficient exhaust steam from the auxiliaries to raise the temperature of the entire feed-water fully 120 deg. Fah., and in such a case, in order that the whole of this heat may be absorbed by the feed-water, the hot-well temperature must perforce be 215 deg. – 120 deg. = 95 deg., which corresponds to a vacuum in the condenser of about 27⅞in.

Assuming 60 deg. sea water temperature in home waters and 80 deg. in the tropics, the average vacuum to be expected on a general trader is about 27½in. to 27⅞in., and with this vacuum there is sufficient waste heat available to raise the temperature of the feed-water to the pumping limit of 215 deg. At such a vacuum, moreover, the pressure in the low-pressure cylinder as recorded on the diagram should be equal to at least 12½ lb.

No steam is taken from the low-pressure receiver of the main engines by this system, the feed-water being raised in temperature by exhaust steam from the auxiliaries only. The final questions are, therefore, whether the low-pressure cylinder of a marine engine can be so designed as to record a vacuum of fully 12½ lb. in the cylinder with a vacuum of 27½in. in the condenser, and whether the consumption of steam per indicated horse-power is less at 27½in. than with a lower vacuum.

Ample evidence is afforded that the former can be accomplished by reference to the results obtained in the s.s. Djerissa and other steamers, and with regard to the latter, Dr. Weighton, who vouches for the accuracy of his results, says that from, say, 25in. to 28½in. vacuum the gain in steam economy in a suitably designed engine is constant per inch of vacuum, and amounts to about 1¼ per cent. per inch for triples, and 1½ per cent. per inch for quadruples.

The economy to be derived from vacua up to 27in. to 28in. in reciprocating engines has been further confirmed by other reliable experimenters, as, for example, Dr. Stanton, Professors Watkinson, Schrute, Josse, and Stodola, and also by such experienced manufacturers as Belliss and Morcom, Willans and Robinson, and Browett, Lindley and Co.

Moreover, the practical results now being obtained at sea by this system of working marine engines amply confirm the correctness of recent technical anticipations.

London, June 13th. MARINE ENGINEER.

SIR,—In your last issue there is an article on "The Value of a Vacuum" in which you state that "the gain by raising the vacuum from 27in. to 28in. was, say, 5 per cent., but raising it from 28in. to 29in. it became 6 per cent."

In my remarks on Mr. Morison's paper such a statement was made by me, but it referred to steam turbines and not to reciprocating engines. The results obtained with reciprocating engines at the Armstrong College were stated by Dr. Weighton to be as follows:—

Vacuum Rise from 25in. to 28½in.

Saving in steam per B.H.P.	Per cent.	Increase in B.H.P.	Per cent.
Quadruples	5.1		5.9
Triples	4.2		5.0
"	3.45		4.44
"	3.0		3.27
Average for triples	3½		4¼

In your comments on Dr. Weighton's contribution to the discussion you state:—"To get great accuracy he tells us that he made a series of five minutes' experiments. What this means precisely we do not know."

Those who heard Dr. Weighton understood him to mean that experiments on the effect of vacuum involved very delicate measurements of temperature, and in order to obtain thoroughly reliable data he had, by experience, found it necessary to allow sufficient time to elapse between each reading to permit the condenser structure, pipes, &c., to adjust themselves uniformly to particular temperature conditions, and not until perfect stability in temperature had been maintained for a period of five minutes did he accept a reading as being correct.

Those who have had experience in condenser tests will appreciate the length of time necessary in order to arrive at such a stability in temperature, so that your comments on five minutes' experiments casts some undesirable reflections on the research work of the Armstrong College, when, as a matter of fact, Dr. Weighton, in the extract you quote, was relating how easy it was to get erratic results, and was impressing on his hearers the very great importance of accuracy. It is, however, this strict accuracy which has always been associated with Dr. Weighton's work that has rendered the results of his researches so exceedingly valuable to the engineering world. M. G. S. SWALLOW.

West Hartlepool, June 12th.

SKEFKO BALL BEARINGS.

SIR,—Our attention has been drawn to an article appearing in the last issue of your valuable paper in which it is stated that "Skefko" ball bearings are being introduced into this country from the Continent by the Unbreakable Pulley and Mill Gearing Company, Limited, of Manchester.

As this statement is somewhat misleading, we trust you will publish the following explanation:—The "Skefko" Ball Bearing Company, Limited, is an English company, with offices at Carlton House, Regent-street, London, S.W., and works at Luton, Beds, and was formed to manufacture and sell "Skefko" self-aligning double-row ball bearings under Wingquist's Patents Nos. 24,931, 1907, and 17,069, 1908.

We have appointed the Unbreakable Pulley and Mill Gearing Company our sole concessionaires for supplying these bearings for line shafting and mill gearing only; but all bearings for general purposes are invariably supplied by us direct or through our accredited provincial representatives.

London, S.W., May 8th. (THE SKEFKO BALL BEARING CO., LTD.) GRAHAM J. FRANCIS, Manager.

INSTITUTION OF NAVAL ARCHITECTS.

JUBILEE MEETINGS, 1911.

THE preliminary programme of the International Congress in Naval Architecture and Marine Engineering, with which the Institution of Naval Architects celebrates its jubilee, is as follows:—

Monday, July 3rd.—Evening: Reception at the Royal United Service Institution.

Tuesday, July 4th.—Morning, 11.30 a.m.: Opening of the International Congress by H.R.H. the Duke of Connaught, K.G., in the Connaught Rooms, Great Queen-street, near Kingsway. Luncheon at the Connaught Rooms. Afternoon: Visit to the Coronation Exhibition, Shepherd's Bush. Evening: Reception given by the Right Hon. Lord Brassey, G.C.B., past-president of the Institution.

Wednesday, Thursday and Friday, July 5th, 6th and 7th.—Mornings, 11 a.m. to 1 p.m.: Reading and discussion of papers in the Halls of the Institution of Civil Engineers and the Institution of Mechanical Engineers.

Wednesday, July 5th.—Afternoon: (*a*) Opening of the National Experimental Tank at the National Physical Laboratory, Bushey House, Teddington. (*b*) Visit to the Festival of Empire to witness the Pageant of London in the grounds of the Crystal Palace. (Note—*a* and *b* are alternative.) Evening: Grand Festival Concert in the Queen's Hall. The choir will consist of 240 voices, selected from the Leeds Festival Chorus of 1910, and the orchestra will be composed of 110 past and present members of the Royal College of Music. The concert will be under the direction of Sir Charles Villiers Stanford, D.C.L., and the vocalists will include Miss Agnes Nicholls and Mr. Plunket Greene. Solo pianoforte, Mr. Percy Grainger. Supper in the Queen's Hall.

Thursday, July 6th.—Evening: Banquet to the delegates and representatives, at the Connaught Rooms, Great Queen-street, near Kingsway.

Friday, July 7th.—Afternoon: River trip down the Thames to visit the docks and shipping of the Port of London. Evening: Reception at the Savoy Hotel, given by his Majesty's Government.

Saturday, July 8th —Afternoon: Visit to Windsor Castle, by command of his Majesty the King.

The above programme is subject to modification; the final programme will be issued later.

The following papers are to be presented at the jubilee meetings:—

France.

"The Rational Application of Turbines to Ship Propulsion," by Professor A. Rateau, of the Ecole des Mines.

"Notes on the Collapsing of Beams and Elastic Curve Slips," by Professor Marbec, of the Ecole du Genie Maritime.

Germany.

"Our Present Knowledge of the Vibration Phenomena of Steamers," by Konsul Dr. O. Schlick, member.

"The Scientific Study of Naval Architecture in Germany," by Professor O. Flamm, of Charlottenburg University.

Italy.

"Fifty Years of Progress in Shipbuilding in Italy," by Lieut.-Col. G. Russo, R.I.N., member.

Japan.

"Progress of Naval Construction in Japan," by Rear-Admiral Kondo, Director of Naval Construction, I.J.N.

"Progress of Naval Engineering in Japan," by Engineer-Rear-Admiral T. Fujii, Engineer-in-Chief, I.J.N.

"Development in Merchant Shipbuilding in Japan," by Mr. Yukawa, Director of the Mercantile Marine Bureau, and Dr. Terano, of Tokyo University.

"Remarks on the Design and Service Performance of the Transpacific Liners Tenyo Maru and Chiyo Maru," by Dr. Terano and Professor Shiba, of Tokyo University.

Sweden.

"Recent Developments in the Sea Transportation of Ore," by Mr. J. Johnson, member.

United States.

"Development of Passenger Steamboat Construction in the United States," by Mr. Frank E. Kirby, member.

"Results of Tests on Models of Submarines," by Mr. Mason F. Chace, member.

England.

"History of the Institution of Naval Architects and the Progress of Scientific Education in Naval Architecture," by Sir William H. White, K.C.B., LL.D., D.Sc., F.R.S., honorary vice-president.

"Fifty Years' Architectural Expression of Tactical Ideas," by Admiral Sir Cyprian Bridge, G.C.B.

"Warship Building (1860 to 1910)," by Sir Philip Watts, K.C.B., LL.D., D.Sc., F.R.S., vice-president, Director of Naval Construction.

"Fifty Years' Changes in Naval Engineering," by Engineer-Vice-Admiral Sir Henry J. Oram, K.C.B., vice-president.

"Progress in Naval Artillery (1860 to 1910)," by Sir Andrew Noble, Bart., K.C.B., LL.D., D.Sc., F.R.S., hon. vice-president.

"Fifty Years' Developments in Mercantile Ship Construction," by Mr. S. J. P. Thearle, D.Sc., member of Council, Chief Ship Surveyor to Lloyd's Register of Shipping.

"The Marine Steam Turbine from 1894 to 1910," by the Hon. C. A. Parsons, C.B., D.Sc., LL.D., F.R.S., vice-president.

"Armour for Ships (1860 to 1910)," by Mr. Charles E. Ellis, honorary treasurer.

"Some Further Notes on Cavitation," by Mr. Sydney W. Barnaby, member of Council.

THE SOCIETY OF ENGINEERS (INCORPORATED).—The second vacation visit of the present session took place on Thursday, June 8th 1911, when, by the courtesy of the engineers, a party of members of the Society and their friends inspected the works in progress in connection with the extension of the Central London Railway from the Bank Station to Liverpool-street. The work of driving the tunnels is being carried out from a shaft in Bishopsgate, near Acorn-street, and will be continued up to the junction with the company's existing sidings at the Bank. The small running tunnels are 12ft. 5in. internal diameter, each ring being 20in. wide with 4in. flanges, and are made up of four radial jointed cast iron segments, two top segments, and a key whose sides taper slightly in the reverse direction to the keystone of an arch; this admits of ease in erection. The joints between the flanges of adjacent rings and segments are formed of creosoted wood packings, and are bolted together in such a way that the horizontal joints of one ring break joint with their neighbours. The weight of each ring is 33.4 cwts. Under ordinary conditions nine rings or five lineal yards of tunnel are built every twenty-four hours. In the case of the 21ft. 2½in. internal diameter station tunnel, the rings are 18in. wide, with 6⅝in. flanges, and consist of ten radial segments, two top segments and a key. The horizontal joints are machined true to radius, but the vertical joints are made with creosoted wood packings. The weight of each ring is 4½ tons, and the anticipated progress is about five rings or 2½ lineal yards per day of twenty-four hours. The plant at the site of the working shaft consists of two 3-ton cranes for dealing with materials to and from the tunnels, and several compressors for supplying compressed air to the tunnels and for operating the pneumatic hydraulic pumps and grouting pans. There is also an hydraulic intensifier converting a pressure of 750 lb. per square inch to one of 1 ton per square inch. The contractors for the work are Messrs. John Mowlem and Co., and the engineers to the Central London Railway Company are Messrs. Mott and Hay, of Westminster, for whom Mr. H. J. Deane acts as resident engineer.—The annual dinner of the Society was held at the Criterion Restaurant on Saturday, May 27th, the chair being taken by the president, Mr. F. G. Bloyd. The loyal toasts having been honoured, Mr. Alexander Siemens proposed the toast of "The Society," and the president, in his reply, said that the Society had no wish to be in antagonism with other engineering bodies, but rather desired to co-operate with them as far as possible. The toast of "The Ladies" was proposed by Mr. E. B. Ellington, and a reply on behalf of the ladies was given in appropriate terms by Mr. J. W. Jacomb-Hood. At the conclusion of the speeches, which were brief, an adjournment was made for a concert, which was much appreciated, and made a suitable ending to a most enjoyable evening.

POPPET-VALVE STEAM ENGINE.

THE Walschaerts' Engine Works, of Brussels, has recently introduced a new form of steam engine in which the four poppet valves on each cylinder are placed with their centre lines at an angle of about 30 deg. with that of the piston, which is bevelled to fit closely to the inside face of the poppets in such way that in working the clearance between them is reduced to about 0.5 or one-half per cent. of the steam volume swept by the piston at each stroke.

Reduction of clearance space by fractional amounts as a means to steam-engine economy opens up questions which have ceased to exercise the same attention as formerly. But in Belgium all mechanical details helping to efficiency and economy in reciprocating engines are carefully studied, with unbroken faith in the superiority of this class of motor, as was so strikingly displayed at the recent Brussels Exhibition, where the turbine was hardly given any place. Admitting the fact that the reciprocating engine is unsurpassed for economy with variable loads, the continued improvement of details in this type appears justified.

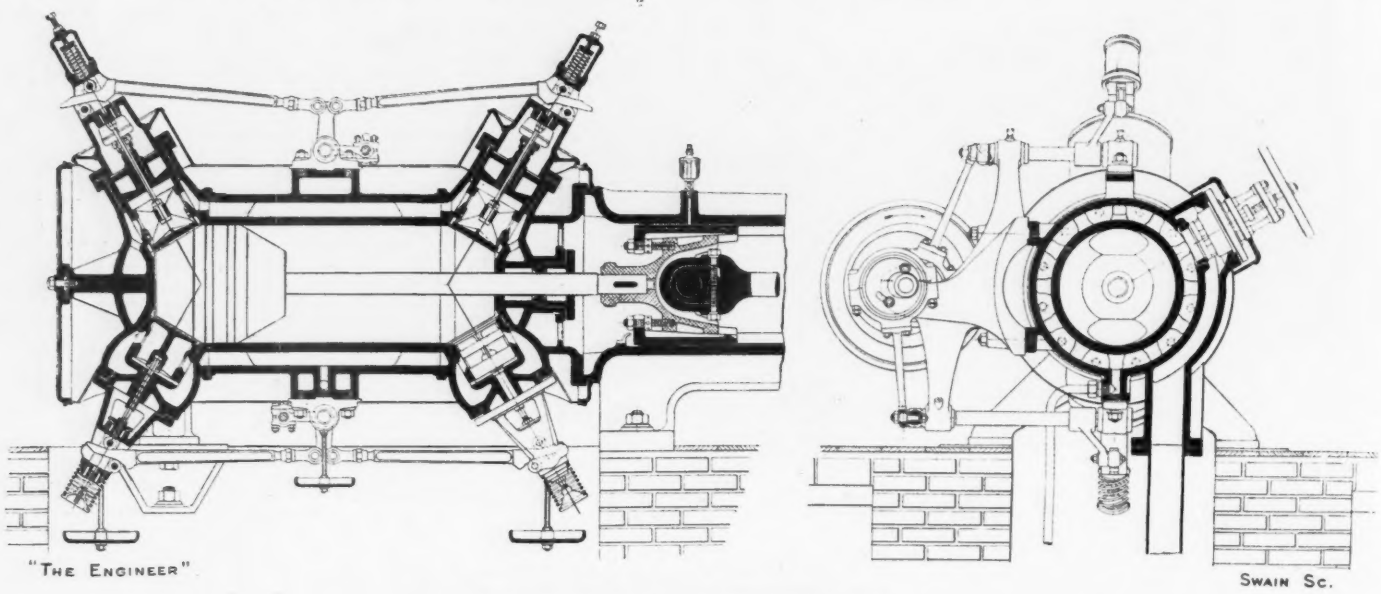


Fig. 1—CYLINDER OF HORIZONTAL STEAM ENGINE

It will be seen by reference to Fig. 2 that the steam or admission valve is single-seated, while its cylindrical part is fitted with rings, which render steam-tight the inside periphery of the valve between the steam chest and the extremity of the valve liner. The wear of these segments is said to be very slight, contrary to the case with piston valves, which, in traversing the ports, are subject to grooving effects from the bridges which carry them. The end of the valve-chest liner forms the single seating for the valve, and is held up by the end of the valve chest, which in turn is secured by the bolted valve-chest cover. By means of the single-beat valve a more perfect closing is realised, by avoiding the well-known practical difficulties experienced with double-seated valves. For the exhaust a different form of the valve is introduced without the rings for condensing or compound engines; or the valve in other cases is single-seated and non-balanced.

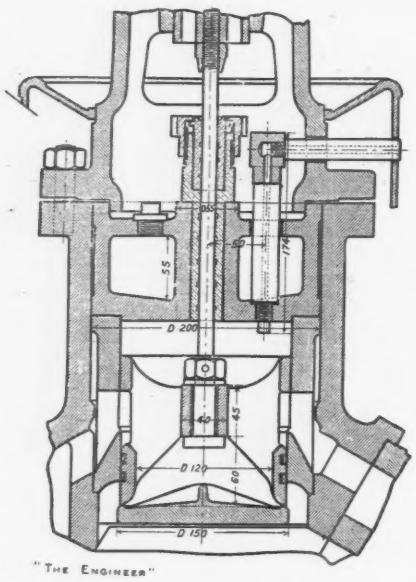


Fig. 2—ADMISSION VALVE

This absence of balancing is possible in view of the fact that during the admission, with the exhaust valve resting on its seat, the mechanism for the latter is subject to no stress. At the end of the expansion, just when the exhaust valve is about to open, the pressure in the cylinder rarely exceeds 14 lb. above exhaust pressure, and this is sufficiently low to overcome with ease the resulting effort against the valve mechanism.

In other cases—for instance, in non-condensing engines working light load in which the steam pressure during expansion may descend to less than atmospheric pressure—it is preferable to balance the valve, otherwise at such moments, if the spring is not very strong, the valve may rise and chatter on its seat. Further, when the apparatus run by the engine is subject to sudden intermittent demands for power, the governor swerves under the change, so causing admissions up to 50 per cent., provoking excessive terminal pressures and undue stress on the exhaust valves, &c. To meet these cases, the Walschaerts' engine is fitted with a single-seated exhaust valve which can be balanced at will.

The arrangement consists of a disc, fitted with rings cast in one with the valve disc proper, as shown in Fig. 3. To balance the single-beat valve shown it is obvious that the admission of steam from the exhaust cavity to the back of the piston valve equilibrates the pressure on the two opposite faces. This connection is made by means of the small steam way shown in the steam-chest liner ending behind the valve in a two-way cock, which opens to a pipe either leading outside the cylinder or to the space behind the piston valve. A quarter turn of the cock suffices to obtain balanced or non-balanced working of the valve.

As the general drawings show, the entire cylinder is effectively steam jacketed by the admission steam, and an endeavour is made to heat the disc of the valve, forming as it does an effective portion of the cylinder wall's interior surface. The valve is cast with an interior cavity into which steam is admitted by a small inverted valve held up by a spring and working similarly to an anti-vacuum valve—see details Fig. 3. During steam admission to the cylinder the valvette yields to the pressure, and admits high-pressure steam into the cavity of the single-beat valve. After cut-off the pressure inside the valve automatically closes the valvette against the lesser pressure in the cylinder, so enclosing steam of the pressure of admission. Provision is made for the escape of the very small amount of condensation water precipitated in the disc valve by means of a perforation in the centre of the valve spindle itself, a little cock here allowing the beads of water to escape as fast as they form in the cavity—Fig. 3.

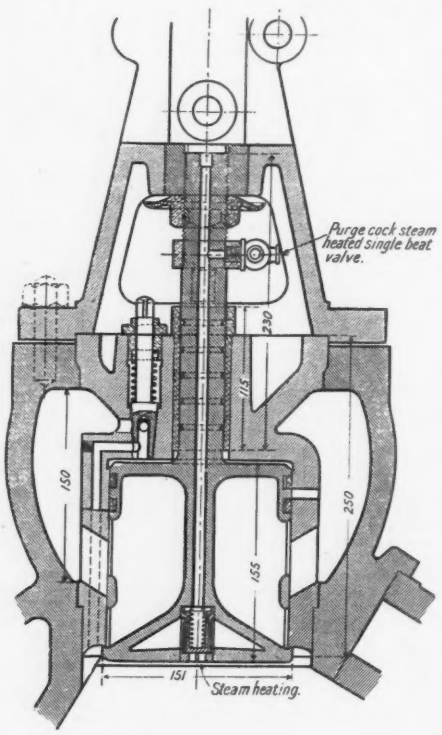


Fig. 3—EXHAUST VALVE

The operation of the poppets is effected by a modification of the usual trip-gear mechanism, the cams of suitable profile transmitting the time movements through rollers to the valve stems. The driving gear for the oscillating rods carrying the admission cams is derived from an excentric whose throw and angle are variable by means of the new Walschaerts-Recke system of governor.

SCOTTISH MINING DURING 1910.

FROM the reports for 1910 of Mr. W. Walker (H.M. Inspector of Mines for Scotland under the Coal Mines Acts, the Metalliferous Mines Act, and the Quarries Act) just issued, it appears that the total number of persons employed in and about the mines under the Coal Mines Acts was 137,873, being an increase of 4268 as compared with 1909. Underground the increase was 3130. The total number of mines at work during the year was 509, as against 511 in 1909. The total output for the year was 46,205,552 tons, or an increase of 1,749,997 tons as compared with the previous year. The output of coal was 41,335,132 tons, or an increase of 1,566,767 tons The number of collieries at which coal-cutting machines were in use was 168, and the quantity of mineral obtained by them was 5,873,455 tons, or an increase of 1,403,491 tons. Of this quantity 4,616,887 tons were obtained by 425 machines driven by electricity, and 1,256,568 tons by 156 machines, the motive power of which was compressed air. During the year 195 separate fatal accidents occurred in and about mines classed under the Coal Mines Regulation Acts, causing 209 deaths, or an increase of 17 in the number of accidents, and of 9 in the number of lives lost as compared with 1909. To machinery were due 9 fatal accidents, causing the death of the same number of persons. No less than 5 of these were caused by persons being caught by bar coal-cutting machines when operating them at the coal face. Accidents from this cause have occurred in former years, but they have never been so numerous as during the year under notice. Nine were killed by two accidents due to overwinding, and at the inquiries in connection with both of them they were found to be due to lapses or mistakes on the part of the winding engineman. At neither of the collieries were detaching hooks or controllers attached to the winding engine to prevent overspeed and overwinding provided.

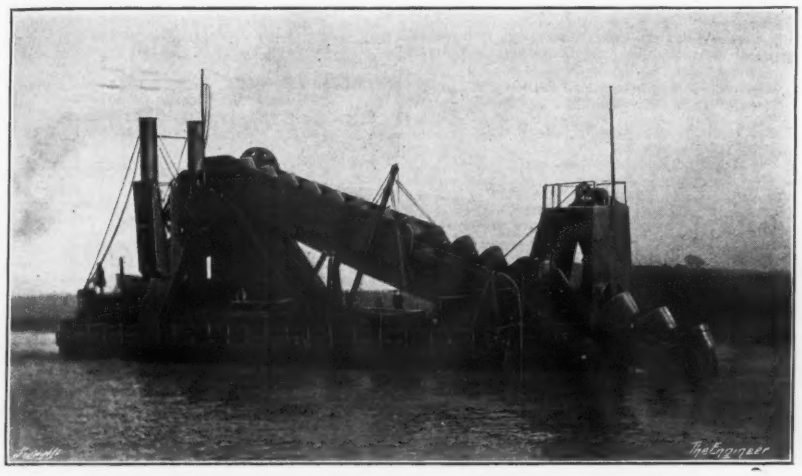
CALEDONIAN LOCOMOTIVES AND SUPER-HEATED STEAM.

FOR a considerable time past experiments have been conducted by the engineers of the Caledonian Railway Company with engines specially designed for using superheated steam, and it is understood that the results of the experiments have been to a considerable extent in favour of this type of engine. Two double runs are being made each day with an engine drawing express trains between Glasgow and Edinburgh, the engine being the fourth of the type constructed at St. Rollox works from the designs of Mr. John F. McIntosh, locomotive superintendent. All four engines are now working express passenger trains on various sections of the Caledonian system, and the details of their coal consumption are being noted and compared with those of ordinary locomotives. From the experiments already made it has been proved beyond doubt that economy of fuel and of water is secured. On the other hand, more skilled driving is required, and also closer attention to what is necessary in the way of repairs.

The Caledonian Company is believed to be about to build six new goods engines fitted with a superheating arrangement from the designs of Mr. McIntosh. Comparisons were recently made between two sister engines, with practically equal weights behind the tender, one a superheater, the other not. The former had a tender carrying 4600 gallons of water and 6 tons of coal as against the other with only 4300 gallons and 4½ tons of coal. The figures taken were for six journeys—three each way—Perth to Carlisle and back, 900 miles. The actual saving in the case of the superheater engine was 7½ tons of coal and 12,180 gallons of water. The only item on the other side was an extra half-gallon of oil for the six journeys; 3 gallons of high flash superheat oil instead of 2½ gallons of the usual kind being used for cylinder lubrication.

STATIONARY PONTOON DREDGER FOR THE TEES

FLEMING AND FERGUSON, LIMITED, PAISLEY, ENGINEERS



RIVER TEES IMPROVEMENTS.

IN continuation of their scheme for the improvement of the river, the Tees Conservancy Commissioners have during the past year had 417,963 cubic yards of material dredged and removed at a net cost of £22,432 18s. 5d., this being at the rate of 1s. 1.51d. per cubic yard. About two-thirds of the total amount of dredging done during the past year was in very hard boulder clay; and there were removed, chiefly from the workings of the dredgers, 1651 stones, varying in weight from 5 cwt. to 4 tons each; also 19 tree trunks, varying in length from 10ft. to 20ft., 16 tree roots and stumps, and 107 miscellaneous obstructions. Of the total of 1651 stones, 1523 were removed by dredgers Nos. 6 and 7, without the aid of divers. Having regard to the work that will be undertaken by the dredging plant during the current year, it is estimated that the expenditure of the Tees Conservancy Commissioners upon dredging during the next twelve months will be about £30,000.

In the accompanying engraving we illustrate a new stationary pontoon dredger—No. 8—recently constructed by Fleming and Ferguson, Limited, of the Phœnix Works, Paisley, to the requirements of Mr. G. J. Clarke, M. Inst. C.E., the engineer of the Tees Conservancy Commissioners. This vessel has now been introduced into regular service. It has a length overall of 136ft., a mean breadth of 30ft., and a moulded depth of 10ft. 6in., and is designed to raise 700 tons of material per hour from a depth of 38ft. when working in the river; and as it has been specially designed for dredging close up to the quay walls, the forward end has been cut away at a sharp angle, so that the buckets can dredge down to a depth of 30ft. when the fenders at the fore end are against the walls.

The vessel was built throughout to Lloyd's special survey, and is fitted with compound surface condensing engines having cylinders of 16in. by 33in. by 24in. stroke for driving the dredging gear. Steam is supplied by two marine boilers of the Scotch type, having a working pressure of 120 lb per square inch, and each boiler is capable of supplying sufficient steam for driving the dredging gear. There are two of Fleming and Ferguson's mooring winches at the fore end and one at the stern; and the vessel is also fitted with the builders' latest special type of ladder-hoisting engine and shoot. There is a complete set of auxiliary machinery and auxiliary condensing plant, and the gearing throughout the vessel is all of cast steel, having machine-cut teeth; and we understand that during the recent official trials there was an absence of noise and vibration during the working of the machinery.

THE COMMERCIAL AND TECHNICAL RELATIONS OF ENGINEERING DESIGN AND WORK.*

By THOMAS FRAME THOMSON, M. INST. C.E.

IT is not my intention this evening to attempt a careful treatment of any of the details of the commercial knowledge which you are to be encouraged to study. I shall rather try to open out to your view the general aspects of the subject, leaving to subsequent lecturers the treatment of those branches which their special knowledge will enable them to deal with as experts. I shall not even pretend to offer you a coherent and logical address, but rather a collection of ideas and suggestions, as they have occurred to me, bearing upon the matter in hand.

One of the most valuable mental faculties for creative work, whether tangible or intangible, is a properly cultivated power of imagination. On the technical side of engineering this is so obvious as to be a mere platitude. The ability to form a correct mental picture of the structure required to obtain a given result, not only cuts out a vast amount of tentative work by directing the mind more or less into the most suitable channels of study, but also gives its possessor greater confidence in the final outcome of his investigations. Applied to commercial and industrial questions, it lifts them above the pounds, shillings and pence point of view of the shopkeeper, by enabling the mind to grasp them as realities of the social and economic machine, and to see behind and beyond the mere rows of figures by which they are defined. That is a point of engineering which very few engineers pay sufficient attention to. Practically every kind of engineering work must in one form or another affect the social conditions of some part of the population, and unless that ultimate result is properly kept in view, with proper relation to its earning capacity, there is bound to be friction between the authorities who represent the interest of the public and the capitalists who provide the money with the intention of making a profit. I am happy to say that all over the world the interdependence is becoming more and more recognised, and the sharp lines which separated capitalists from public authorities are now not so distinct.

But the value of imagination in business is not limited to the greater efficiency and rapidity with which it enables analytic and synthetic methods to be applied; perhaps its greatest value is the added interest which it gives to every problem, so that the work involved in its solution becomes an engrossing pleasure. Regarded in this light, the commercial aspects of engineering are devoid of any sordid element, and can take rank with its technical aspects as deserving of respect and admiration. I have seen more than one instance of the successful development of a great conception being accompanied by large profits, even considerable fortunes; instances in which I can vouch from personal knowledge that the driving force was sound and correct imaginative power, and the monetary consideration the ballast which steadied its action.

At the risk of appearing to labour this branch of our subject, I feel bound to emphasise it in the strongest terms at my command. The object of these lectures would be hopelessly perverted if they tended to lower the ideals of which every engineer is proud. On the contrary, it is my earnest hope that one of the results will be to impress upon you that permanent commercial and financial success not only may, but must, be based on the same principles of reliability, efficiency and security that you apply in your technical work. It is not true that either commerce or finance are disreputable either in their objects or their methods. There have been and are dishonest merchants and financiers, just as there have been and are dishonest engineers. But if we believe, as we do, that the great majority of the members of our profession are devoting to it the best of their ability and energy, and for objects beneficial to the community, so also we must believe that those other two great classes of society are chiefly composed of men like ourselves, animated by the same principles and engaged in operations not less worthy than our own. To have a sufficient and intelligent understanding of the principles and practice underlying their operations, so that where our work is precedent, parallel or supplementary to theirs, we may adjust it to produce the greatest combined efficiency, is no discredit to an engineer. On the contrary, the absence of such working knowledge prevents him from pulling his share of the load, and imposes needless difficulties and risks upon the other units of the team. Not only so, but the very nature of an engineer's training and instincts provides him with many of the habits of thought and action which are essential to the soundness of commercial and financial operations. He is imbued with the importance of painstaking investigation of all essential detail and the avoidance of non-essentials, with the importance of a large factor of safety, and with the necessity of provision for unforeseen contingencies. All these make him a valuable collaborator, provided he is possessed of the working knowledge to appreciate their application to other activities than his own purely technical branch.

Stagnation is a condition inconsistent with the life of a healthy organism. Growth and decay are the active manifestations of life. By the prevention of decay and the stimulation of growth maximum efficiency is obtained. The surest way of obtaining profit is to prevent loss. Any enterprise that is radically sound cannot help growing—that is, making profits—if every element of waste and loss can be eliminated. As a general rule, men's minds fasten more readily on the attractive possibilities offered by the prospect of stimulating the growth of an enterprise than upon the more prosaic feature of stopping all possible leaks. Stated in order of importance, I consider the main factors of success for an industrial enterprise to be:—

(1) Safeguard from waste.
(2) Provision for expansion.
(3) Stimulation of growth.

These considerations may appear at first sight to be more properly within the functions of the operating engineer than of the designer and constructor, but a moment's thought will show that, as the former has to work with the equipment provided by the latter, his work will be either facilitated or handicapped by that equipment. Consequently, the designer and constructor, to be of the greatest value, must think backwards from the field of action of the operating engineer to the starting point of their own problems.

One of the most valuable features of design, from the point of view of assistance rendered to the operating man, is that of adaptability. By that I mean keeping in view in all parts of a design the probability that its working conditions will not conform precisely to the forecast upon which the design is based, and if the design does not or cannot be subjected to modifications during or after construction without excessive expense, the operating engineer will be hampered in successfully applying it to the work to be done. One of the simplest illustrations of adaptability is that of providing ample space, not merely for growth by extension of works, but for improvement within the limits of the original work.

Simplicity and the use of standard appliances and materials are very important qualities in a design considered commercially. By keeping the design down to the simplest elements compatible with efficiency, the variety of spares to be kept in stock is reduced to a minimum, whilst the use of standard articles, which can be obtained on short notice by letter or wire, keeps down to a minimum the amount of dead capital lying idle in the form of stock at any given time, and reduces the time during which it is lying dead, thus saving the interest upon it. A very well-balanced judgment is required to draw the line where economies resulting from increased complication—as, for example, a multiplicity of auxiliary plant for accessory purposes—detract from instead of adding to the efficiency of the entire combination. On the whole, I have personally always favoured simplicity, even to an extent that may seem to involve some apparent extravagance, say, for example, in the coal consumption of a power station, because I have felt that the human element in the supervision and control of the plant is quite as large a factor in the final economy as the mechanical equipment through which it operates. There is a certain limit of complexity, different, of course, in each case, beyond which the mental effort required to keep continually feeling the pulse of the various elements is too great for the average man; in the words of the late Lord Goschen, he becomes "too much oppressed with detail." When the controlling mind is overburdened, loss of efficiency is inevitable, and just as worry produces physical inefficiency in the body, its counterpart operates similarly in the organism whose muscles are of steel or copper and whose blood is steam or electricity.

You may be inclined to ask me what all this has to do with the commercial aspect of engineering work. What I have just been saying has had the object of illustrating by a line of thought with which your studies and reading must have familiarised you, the central feature of my remarks to-night, viz., that the perfection of engineering detail falls short of your whole duty if it is not accompanied by a judgment and imagination capable of appreciating the non-technical conditions which, in the end, control and limit its scope in each case. I have led you up to the appreciation of one of these, the human or brain element in the engineering organism, which is already familiar to you. But your contact with the human element does not end with the labourers, foremen, superintendents and managers. Behind and beyond all these, too often separated from them by an empty void, are the brains whose financial ability secures the means by which your works come into existence. Like yourselves, these brains work on formulæ derived, consciously or unconsciously, from experience, by rule of thumb, and the lessons of trial and error, or by processes of logical analysis quite as rigid and sound as your mathematical studies. The functions of their formulæ are capital and profit; their great common denominator is money. What we have all to realise is that just as much as steel and concrete, money is one of the things we have to deal with in engineering structures. In the initiation of an enterprise they rely upon you to provide them with estimates of first cost, probable earnings, and probable expenses, in which the elements of chance or guesswork are reduced to a minimum. They rely upon you to gauge the unforeseen contingencies, and they rely upon you to have qualified yourselves, by your own experience, by voracious assimilation of the experience of others, by painstaking analysis and synthesis of these experiences, to probe the innermost recesses of the enterprises upon which you have to pass judgment, and further, perhaps most important of all, to be able to lay the results before them in terms not merely intelligible to them, but so intelligible that they can themselves criticise your deductions and be convinced in their own minds, and by their own judgment, of the soundness of your conclusions. To an experienced engineer, thoroughly saturated with the physiology of his special branch of the profession, the process of forming a mental picture of a project, though involving laborious work, is almost automatic, and the resulting picture is clear and sharp to his mind. The real crux of his difficulty is the effort of projecting into the minds of his associates that same picture with sufficient clearness and sharpness. I am quite aware that I am putting before you an aspect of your duties which, as a general rule, is not demanded of the engineer. Just as the average solicitor is content to cover his own responsibility by submitting his client's case to counsel, so the average financier is similarly content to take the engineer's report as read. For myself, I have never been satisfied to have my expressions of opinion taken as final and conclusive; on the contrary, I frequently put them forward in such shape as to compel criticism from those for whose use they are intended, so that they may have the double satisfaction of arriving at a firm conviction and of realising that it has been reached with their collaboration and not taken for granted. For myself, this process has the great advantage that it provides a valuable check and supplement to my own study of the matter, by bringing to bear upon it the trained intelligence of men who look at it from the point of view of their own wide experience in other directions than my own. To be fruitful it implies, of course, that one's associates are not mere guinea-pigs, but men of keen commercial knowledge and sense of their own responsibility. It involves also a very much greater effort in constructing a lucid exposition of the subject in terms of the special branches of experience which it touches, and the use of much tact and patience and time. And it is precisely in such relationships that the engineer finds the greatest value in general commercial knowledge. For such purposes as I am now dealing with he must be able to look at business with something of the spirit of the banker, the "adventurer" in the good old commercial sense of the word, the lawyer, the accountant, the stockbroker, the municipal councillor, the Minister of State, and even the Head of the Nation, so many are his points of contact with human activities. I am not for a moment advocating that you should be jacks of all trades and masters of none. But I do advocate that you should be pastmasters in the art of taking pains, and whilst your greatest pains should be devoted to the mastery of your own profession, a suitable proportion of your time and ability and labour should be devoted to making yourselves familiar with the methods of work and ways of thought of other professions and businesses.

But generalities are a very easy and comfortable way of filling out an address, and leave the hearer much where he was before if they are not crystallised into some practical suggestion. An ounce of practice is to-day worth just as many pounds of theory as it has always been, probably more, as theory to-day is more easy of access and less laborious in acquisition. If you will permit me, I shall indicate shortly from my own experience how I obtained such little commercial knowledge as I possess, and which I can assure you I have found to be of immense value, not so much in itself, but for the reason I have been harping on all the evening, that it enabled me to picture to myself the point of view of my associates in business.

Whilst I was serving my apprenticeship as a civil engineer I attended on two successive winters' series of evening lectures on mercantile law. These were delivered by a brilliant young solicitor, who dealt with the general principles upon which mercantile law has been evolved. No engineer however subordinate is devoid of contact with some and probably many contracts. If he is entirely ignorant of the principles of law relating to contracts, as, for example, the legal value and effect of verbal understandings, verbal modifications of written agreements, or written modifications of agreements under seal, he may very well find that precautions he had taken in such connections crumble away from him in a court of law or arbitration like so much rotten timber. We all have to use cheques, and most of us at some time or other come into contact with bills of exchange, telegraphic transfers, and problems of foreign exchange, all of which have a legal side that is important for us to have some familiarity with. The law of evidence and its various degrees of stringency, as, for example, in arbitration, as compared with courts of law, is one that touches us at many points. The laws relating to common carriers, land purchase, railway rates insurance, shipping matters, and many other subjects, come at one time or another within the horizon of most of us. In carrying out a contract, or in supervising a contractor, your position will be immensely strengthened if you can yourself intelligently understand and trace out the ramifications of the various accounts, analyse them in such a manner as to bring out the particular feature you require to ascertain, and recast them into statements which check up at all points with the accounts themselves, but go further than the accounts in showing the grouping of expenditure or receipts so as to throw important sidelights on special aspects of cost or revenue.

The engineer who makes estimates of results without having realised the bearing of such questions as depreciation and renewals, discount on the issue of securities, sinking funds for redemption of capital, will soon find that "facts are chiels that winna ding," and, to mix the metaphors, come home to roost in very disagreeable guise. Knowledge of "the sweet simplicity of the 3 per cents." is a poor equipment for a man who may have to

* Frame Thomson Lecture, Friday, 28th April, 1911.

advise upon the prospects of enterprises ranging in security from the humdrum stability of a loan with the guarantee of a Great Power to the mercurial attractions of a new mining development. If you take the trouble to note from time to time the brilliant forecasts of the engineer's reports embodied in railway or other industrial prospectuses, and keep a lookout for the subsequent results when the enterprises get under way, you will realise that even the glamour of a Westminster reputation will fail to avoid disaster to schemes commercially defective. Or if you will occasionally take up the balance sheet and profit and loss account of a railway, tramway or industrial company, which are all things you can get for nothing, and get an accountant friend to explain it to you, you will be astonished at the new light such studies will throw upon the principles of industrial operations.

No amount of care or study will absolutely guarantee success for any enterprise, but care and study intelligently applied will at any rate reduce the adverse contingencies to the limits of ordinary business risks. And that is all our clients ask from us. They do not want impossibilities. On the contrary, they want us to make our studies sufficiently carefully, and when we can prove to them they have been made carefully enough they do not blame us for what goes wrong afterwards. That is simply the ordinary business risk, and is covered by the surplus of successes over failures. They may even make all the difference between success and failure, as has been proved over and over again in cases where water-logged concerns have been pulled round and set on their feet by men capable of seeing the defects and applying the remedies. The trouble is very seldom on the surface, and it is very rarely due to any one kind of cause. The construction may be good of its kind, the management may be good of its kind, the accounting may be good of its kind, the financing may be good of its kind, but they may each be just sufficiently not of the right kind for the purpose to produce weird results. To correct such a situation, or to foresee and prevent it, obviously requires some knowledge of all these elements, and not merely complete knowledge of one of them. Or, again, in the case of inventions which you may originate or be asked to report upon, it is of the greatest importance that your keen appreciation of a bright idea should be qualified by some understanding of the obstacles and difficulties which lie in the way of its practical application, and of the conditions of working essential to its establishment as a going concern. I have seen many instances of the waste and loss caused by want of commercial knowledge on the part of clever inventors. One of their most common errors is that, when they have induced their friends to provide money for its development, instead of pushing on the production and sale of their article, they exhaust the capital in continual attempts to improve it. The result is that the money and time which would have enabled them to obtain a firm market for an article sufficiently good is frittered away in experiments for improving it, and the whole thing ends in recriminations and failure. Incidentally this reminds me of a very important relationship between time and money. When capital is being expended upon an asset that will become revenue producing it is usually profitable to spend it as rapidly as possible. Every month's delay in construction means a month's loss of revenue, so that methods of construction which save money at the expense of loss of time must be very suspiciously scrutinised, and, on the other hand, methods which save time at the expense of money should be studied with a very friendly eye. Loss of time is a two-edged sword, it cuts into profits, both by loss of revenue and by increase of interest and general charges. Extra cost to save time increases interest charges, but gains revenue to offset them, besides saving general charges. Spending money is not in itself extravagant, it is often the greatest economy.

In concluding what has been but a rambling talk upon a few general features of a wide subject, I should like to urge upon you the belief that there is no kind of knowledge that does not find its niche of utility at some time or other in your careers. The habit of picking up and assimilating all sorts of information that present themselves will not only maintain your minds in a state of keen receptiveness, but will provide you at unexpected moments with just such knowledge as you urgently require, and which, but for such habits, you would be at a loss to know where to find. In a very special degree this applies to making copious notes of all information, wherever you find it, of the cost of work and materials. There is no notebook so valuable in the active period of an engineer's career as one containing every price, contract amount, detail of cost of working, or other form of data upon the relation between money and work, that he has come across in his earlier years. It is not sufficient merely to note these data and index them, you must expand them and reduce them to units of general application. The continual practice of this sort of thing provides you at length with something infinitely more valuable even than a vast collection of notes, viz., with an instinct for appraising costs by an unconscious mental process. This instinct when acquired carries you a great deal further than the limits of the special lines with regard to which your cost data have been collected. There is a subtle but very real analogy between the cost of work of different kinds and executed under different conditions, the appreciation of which is perhaps more of a natural talent than an acquired accomplishment, but is capable of great development by continuous assimilation of all available material respecting costs of all kinds.

One or two points have been suggested to me by members of the students' committee, to whom I submitted the draft notes for this address. One gentleman has asked me to express my opinion on the following questions:—

When a student has completed his articles or college training should he—

1. Go to a contractor or a consulting engineer?
2. Go to a large firm or a smaller one?
3. Stay long with any one firm before the age of 25 or 27?
4. Specialise in any one branch before that age and to what extent?

The answers to these questions depend so much upon the opportunities open to each individual that they would probably vary very much in different cases; but, speaking generally, I think that a short period spent with a good contracting firm would be a most useful part of an engineer's training, as it brings him into more direct daily contact with cost problems, and, if practicable, should precede his entrance into a consulting engineer's office. A smaller firm doing a somewhat varied business I should consider preferable to a large firm where the individual's work would be restricted to one part of the general routine. Experience with more than one firm is bound to be valuable, as the comparison of different methods will stimulate the faculty of observation. Specialisation in a broad way is inevitable now-a-days, but the final specialisation into one branch of the profession is likely to depend more upon opportunity than selection, and should be postponed in most cases until some definite opportunity clearly calls for it. There are other considerations that affect an engineer's decision in such matters, such as the nature of the personal backing that he can command, and the extent to which he can choose for himself independently of making his living entirely on his own resources, but as a general rule I should say that up to the age of 30 breadth of experience rather than extreme specialisation should be his objective.

INSTITUTION OF MECHANICAL ENGINEERS.

ZURICH MEETING.

In accordance with previous announcements, the summer meeting of this Institution will be held in Zürich and Northern Switzerland, and will begin on Monday, 24th July. The arrangements have been made in conjunction with Colonel P. E. Huber, Professor Dr. A. Stodola, Mr. Jacob Sulzer, Professor Dr. W. Wyssling, and others, including the owners of numerous power stations and other works in Switzerland. The following papers have been offered for reading and discussion, and will be read as time permits, but not necessarily in the order here given:—

"Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines," by Professor Dr. Franz Prásil, of Zürich.

"Some New Types of Dynamometers," by Dr. Alfred Amsler, of Schaffhausen.

"Railway Electrification in Switzerland," by Mr. Emil Huber, of Zürich.

"Hydraulic Power Works and their Construction, with Special Reference to the Difficulties Encountered and the Methods of Overcoming them." by Mr. L. Zodel, of Zürich.

"Steam Turbines," by Mr. H. Zoelly, of Zürich.

"Diesel Oil Engines," by Mr. Jacob Sulzer, member, of Winterthur.

"Rack Locomotives of Switzerland," by Mr. Pfander, of Winterthur.

The pr gramme of visits, &c., is as follows:—

Sunday, 23rd July—Arrival in Basel.

Monday, 24th July.—Alternative whole-day excursions:—Basel to Zürich. Laufenburg: Drive to Rheinfelden; visit power station (a row of 1000 horse-power units supplying power to factories) and the ancient fortified town; train to Laufenburg; visit the large power station (under construction; 39ft. head, formerly rapids; 50,000 horse-power) and the picturesque town and castle; dinner in the Rhein-Soolbad Hotel; train to Zürich (arrive about 9 10 p.m). Baden: Train to Rheinfelden; visit power station (a row of 1000 horse-power units supplying power to factories) and the ancient fortified town; train to Baden; visit the works of Brown, Boveri and Co; tea; train to Zürich (arrive about 7 p.m.). Rheinfelden (ladies admitted): Train to Rheinfelden; drive through the ancient fortified town; train to Zürich (arrive about 5.23 p.m.). Wangen-on-the-Aare: Train to Langenthal; electric tram to Bannwil; visit Wangen power station (modern quadruple low-pressure horizontal and other turbines; units 1500 horse-power); electric tram to Langenthal; train to Baden; visit Brown, Boveri and Co.; tea; train to Zürich (arrive about 7 p.m.).

Tuesday, 25th July.—The President (Colonel P. E. Huber) or the vice-president (Mr. Eduard Sulzer-Zeigler, of the Verein Schweizerischer Maschinen-Industrieller) will welcome the President (Mr. Edward B Ellington) and the Council and members of the Institution in the Aula of the Swiss Polytechnikum. Reading and discussion of papers at 10 a.m., Mr. Edward B. Ellington (President) in the chair. Alternative visits: Escher Wyss and Co., Zürich; Oerlikon Machine Works; steamboat excursion on Lake Zürich. In the evening the Institution dinner will be held in the Tonhalle.

Wednesday, 26th July.—Reading and discussion of papers in the Aula at 9.30 a.m., Mr. Edward B. Ellington (President) in the chair. Alternative excursions:—Winterthur: Train to Winterthur; visit the works of Sulzer Brothers and those of the Swiss Locomotive and Machine Company. Schaffhausen (ladies admitted): Either train to Neuhausen; visit Falls of the Rhine; or train to Schaffhausen; visit power station of the Schaffhausen electricity works (low-head and high-head electric station, with accumulation and pumps). Beznau: Train to Döttingen; visit Beznau power station (19ft. head vertical turbines; also steam turbine plant, 2500 kilowatt units) and the weir.

Thursday, 27th July.—Alternative excursions:—Glarus (ladies admitted): Train to Netstal; visit the Löntsch power station (36,000 horse-power, units 6000 horse-power, 120ft. head); luncheon at noon at St. Fridolin Hotel; drive or walk up to the intake at Klöntalersee and on to Glarus (seven miles). Braunwald (ladies admitted): Train to Linthal; ascend (1948ft.) by mountain railway to Braunwald; descend by rail to Linthal; train to Glarus.

Friday, 28th July.—No excursions have been arranged.

Saturday, 29th July.—Excursion from Zürich to Lucerne (ladies admitted): Train to Arth-Goldau; ascend (4042ft.) by mountain railway to Rigi-Kulm; descend by rail to Vitznau; steamboat to Lucerne (arrive 6.45 p.m.).

FORTHCOMING ENGAGEMENTS.

SATURDAY, JUNE 17TH.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to Brighton Corporation Pumping Station at Falmer. 3 p.m.

GEOLOGISTS' ASSOCIATION OF LONDON.—Excursion to Cambridge and Barrington. Leave Liverpool-street, Great Eastern Railway, at 12 noon.

THE STEPHENSON SOCIETY.—Visit to Nine Elms Locomotive Depôt, London and South-Western Railway. Members meet at Waterloo 2.45 p.m., train indicator (Old Station).

SATURDAY, JUNE 24TH.

GEOLOGISTS' ASSOCIATION OF LONDON.—Excursion to Bushey, Oxhey, and Watford Heath. Leaving Euston at 2.20 p.m.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to Lillie Bridge Works of London Underground Electric Railways, S.W. 3 p.m.

TUESDAY, JUNE 27TH, TO FRIDAY, JUNE 30TH.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—Sixteenth Annual Convention at Brighton. For programme see page 490 *ante*.

WEDNESDAY, JUNE 28TH.

INSTITUTION OF CIVIL ENGINEERS.—The nineteenth "James Forrest" Lecture will be delivered at the Institution by Frederick Henry Hatch, Ph.D., M. Inst. C.E., his subject being "Gold Mining in the Transvaal." 8 p.m.

THURSDAY, JUNE 29TH.

THE INSTITUTION OF CIVIL ENGINEERS.—The Annual Conversazione will be held in the Royal Albert Hall, at 8.30 p.m.

FRIDAY, JUNE 30TH.

PHYSICAL SOCIETY OF LONDON.—The Imperial College of Science. "On the Effect of a Narrow Saw-cut in the Edge of a Conducting Strip on the Stream Lines in the Strip and on the Resistance of the Strip," Professor C. H. Lees, F.R.S. "The Capacity Coefficients of Spherical Electrodes," Dr. A. Russel. "Exhibition of the Benkö Primary Battery," Mr. W. R. Cooper. 5 p.m. This meeting takes the place of the one previously arranged for June 23rd, which is cancelled.

MONDAY, JULY 3RD, TO FRIDAY, JULY 7TH.

INSTITUTION OF NAVAL ARCHITECTS.—Jubilee meetings. For programme see page 627.

WEDNESDAY, JULY 19TH.

THE STEPHENSON SOCIETY.—Visit to Swindon Locomotive and Carriage Works (Great Western Railway).

THURSDAY, JULY 20TH.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to the Great Eastern Railway Locomotive Works at Stratford, E. Leave Liverpool-street 1.52 p.m. (platform No. 13).

MONDAY, JULY 24TH, TO SATURDAY, JULY 29TH.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Zurich Meeting, 1911. For programme see elsewhere on this page.

THURSDAY, AUGUST 3RD, TO MONDAY, AUGUST 21ST.

GEOLOGISTS' ASSOCIATION OF LONDON.—An Excursion to the Bergen District, Norway. Leaving King's Cross on August 3rd by special boat train for Hull.

SATURDAY, SEPT. 9TH, TO WEDNESDAY, SEPT. 20TH.

GEOLOGISTS' ASSOCIATION OF LONDON.—September Long Excursion. The first part of the excursion will be devoted to a study of the Geology of Lochaber, including Glens Nevis, Roy and Coe, and Fort William will be the headquarters. The second part of the excursion will be devoted to the Geology of the Broadford district of the Island of Skye, and the headquarters will be at Broadford. Full particulars of excursion may be obtained from Mr. Alfred D. Young, 17, Vicars-hill, Lewisham, S.E.

WEDNESDAY, SEPT. 13TH, THURSDAY, SEPT. 14TH, AND FRIDAY, SEPT. 15TH.

THE INSTITUTION OF MINING ENGINEERS.—Cardiff. Annual general meeting. Further particulars later.

LAUNCHES AND TRIAL TRIPS.

HELVETIA, collier; built by Sir W. G. Armstrong, Whitworth and Co.; to the order of W. Lowden and Co., of Liverpool; dimensions, 389ft. by 52ft. by 30ft. 9in.; engines, triple-expansion, 26in., 44in., 73in. by 48in. stroke, pressure 180 lb.; constructed by George Clarke, Limited, of Sunderland; trial trip, recently.

CLIFTONIAN, steel screw steamer; built by the Northumberland Shipbuilding Company; to the order of J. Mathias and Sons, of Aberystwyth and Cardiff; dimensions, 390ft. by 49ft. by 29ft.; engines, triple expansion, 25in. by 41in. by 69in. by 48in. stroke; pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, recently.

ATLANTICA, steel screw steamer; built by Sir W. G. Armstrong, Whitworth and Co., Limited; to the order of the Atlantica Sea Navigation Company, of Budapest; dimensions, 378ft. by 52ft. 3in. by 26ft. 4in.; to carry 7200 tons; engines, triple-expansion, 26in., 42in., 68in. by 48in. stroke, pressure 180 lb.; constructed by Blair and Co., Limited, Stockton and Co., Leeds; trial trip, recently.

BOHEME, steel screw steamer; built by Wm. Doxford and Sons; to the order of Messrs. Marco U. Martinolich and Co., Lussinpiccolo; dimensions, 386ft. by 50ft. by 28¾ft.; to carry 7600 tons; trial trip, May 23rd.

BRIERTON, steel screw steamer; built by Irvine's Shipbuilding and Dry Docks Company, Limited; to the order of the Brierton Shipping Company, Limited, West Hartlepool; dimensions, 352ft. by 47ft. 9in. by 25ft. 6in.; engines, triple-expansion, 25in., 40in., 67in. by 45in. stroke, pressure 180 lb.; constructed by Richardsons, Westgarth and Co., Limited; launch, May 30th.

KINROSS, steel screw steamer; built by the Northumberland Steamship Company; dimensions, 375ft. by 51ft. 4¼in. by 28ft. 4¼in.; engines, triple-expansion, 24in., 41in., 67in. by 45in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company, Limited; trial trip, May 31st.

CLAN MAGGILLIVRAY, steel screw steamer; built by Sir W. G. Armstrong, Whitworth and Co.; to the order of Cayzer, Irvine and Co., Limited, Glasgow; dimensions, 430ft. by 53ft. 6in. by 29ft.; engines, triple-expansion, 29in., 49in., 80in. by 60in. stroke, pressure 200 lb.; constructed by the Wallsend Slipway and Engineering Company, Limited; launch, recently.

EXFORD, steel screw steamer; built by Craig, Taylor and Co., Limited; to the order of W. J. Tatem and Co., of Cardiff; dimensions, 325ft. by 50ft. by 29ft.; engines, triple-expansion, 25in., 42½in., 69in. by 48in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, June 7th.

CLAN MACKENZIE, steel screw steamer; built by Wm. Doxford and Son, Limited; to the order of the Clan Line Steamers, Limited; dimensions, 445ft. by 53¼ft. by 29ft.; to carry 8500 tons; engines constructed by the builders; launch, June 8th.

VIAGATCH, steel screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Archangel Mourman S.N. Company, Archangel; dimensions, 215ft. by 32ft. beam; launch, June 8th.

GRAIGSTON, steel screw steamer; built by William Grey and Co., Limited; to the order of John Cory and Sons, Limited, of Cardiff; dimensions, 311ft. by 46ft. by 21ft. 7½in.; engines, triple-expansion, 22in., 36in., 60in. by 39in. stroke, pressure 180 lb.; constructed by the builders; trial trip, June 10th.

KINKASAN MARU, steel screw steamer; built by Sir Raylton Dixon and Co.; to the order of Messrs. Mitsui and Co., for trade with Hong-Kong, Shanghai and the rivers of China; dimensions, 393ft. 6in. by 53ft. 7in. by 29ft. 7½in.; to carry 8200 tons; engines, triple-expansion, 26in., 42in., 70in. by 48in. stroke; constructed by Blair and Co., Limited; trial trip, June 10th.

ROKKASSAN MARU, steel screw steamer; built by Sir Raylton Dixon and Co., Limited; to the order of Mitsui Bussan Kaisha, of London and Japan; dimensions, 275ft. by 42ft. 3in. by 20ft. 6in.; to carry 3000 tons; engines, triple-expansion, 21in., 35in., 57in. by 39in. stroke, pressure 180 lb.; constructed by Blair and Co., Limited; launch, June 13th.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Summer Iron Trade.

WITH the arrival of summer, and the consequent restriction of work at the mills and forges, owing to the heat, there is an absence of conditions making for an encouragement of speculative operations or forward buying. Business, therefore, is generally quiet, though on the week a little improvement is apparent. The Coronation festivities will, however, involve a further interruption this month, and any considerable increase in buying is not seriously looked for. A fair volume of employment is maintained in the finished iron branches, where low prices still form the principal subject of complaint. Makers of merchant bars have a good amount of work in hand, and quotations range from £6 5s. to £6 7s. 6d. (delivered). Prices of commoner qualities remain weak, for there has been no cessation of the severe Belgian competition, and local iron of a minimum quality is priced at about £5 16s. 3d. to £5 17s. 6d. and on. Tube strip continues at £6 10s. to £6 12s. 6d., and hoops at £7 to £7 10s.

Galvanised Iron Firm.

Producers of galvanised sheets report that they have fair orders on their books. Quotations are firm; most makers refuse to do business at less than £10 15s. f.o.b. Liverpool, while for some brands £10 17s. 6d. is asked. Plain black sheets are £7 10s. for 24 w.g. material and £8 for 27 and 28 w g. Buyers of galvanised sheets, it is noteworthy, are not giving any more encouragement than they are compelled to the current upward tendency of values. The quantity of galvanised sheets exported during May was 57,424 tons, as compared with 49,773 tons for the same period last year. The value of shipments during the month was £708,574, as against £629 256 in 1910. For the five months of this year the value was £3,378,488, as compared with £3,168,632 last year.

Pig Iron Steady.

The features in the pig iron branch have given place to more stable conditions. Some of the big buyers gave a lead in

buying directly prices broke a few weeks ago, and such contracts were entered into that smelters are now in a comparatively independent position. They are reckoning on the market hardening as it feels the autumn demand, and in these circumstances quotations are upheld. Consumers who have neglected to cover forward may not improbably find it difficult to repair the omission except on terms advantageous to the seller. Prices this week are quoted:—Forge pig iron: Staffordshire common, 49s.; Staffordshire part-mine, 50s. to 50s. 6d; best all-mine Staffordshire forge, 85s.; and foundry, 90s. per ton. Northamptonshire forge iron is 47s to 48s., delivered here; Derbyshire forge, 50s. to 51s.; and North Staffordshire forge, 51s. to 52s. per ton.

Steel.

The trade in raw steel shows further restriction, with prices somewhat easier. The principal cause is the extensive importation of foreign material. The Belgian quotation is £4 9s. for raw bars delivered in the Birmingham district, which is a shilling below recent figures, and an equal amount below the lowest quotation during the whole of last year. So far the finished steel department has escaped this severity of competition, and Staffordshire mills, at any rate, are well off for orders. Values in this department are:—Angles, £6 12s. 6d. to £6 15s.; joists, £6 10s.; plates, £7 to £7 10s. for bridge and tank qualities; and boiler plates, £7 17s. 6d. (Association price).

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

Pig Iron Improving.

ALTHOUGH the market had scarcely recovered from holiday influences, there was a fair attendance on the Iron Exchange on Tuesday, and the feeling in pig iron showed general improvement. In other respects there was little change to note, except that there has been a sharp rise in tin. Quotations:—Pig iron: Lincolnshire, No. 3 foundry, 53s.; Staffordshire, nominal, 53s. 6d. to 54s. 6d.; Derbyshire, 53s 6d. to 54s.; Northamptonshire, 54s. 6d. to 54s. 9d.; Middlesbrough, open brands, 55s. to 55s. 3d. Scotch: Gartsherrie, 61s.; Glengarnock, 59s.; Eglinton, 58s. 6d., delivered Manchester. West Coast hematite, 64s. to 64s. 6d., f.o.t; East Coast ditto, 62s. 6d. to 63s., f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 57s.; Eglinton, 56s. 6d. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 58s.; Eglinton, 57s. 6d. Finished iron: Bars, £6 15s.; hoops, £7 7s. 6d.; sheets, £8 to £8 2s. 6d. Steel: Bars, £6 10s. to £7; Lancashire hoops, £7 7s. 6d.; Staffordshire, £7 7s. 6d.; sheets, £8 to £8 5s.; boiler plates, £7 15s.; plates for tank, girder, and bridge work, £7 to £7 5s.; English billets, £5 to £5 5s.; foreign ditto, £4 10s. to £4 12s. 6d.; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £70; tough ingots, £60; best selected, £60 per ton; copper tubes, 8½d. to 8¾d.; brass tubes, 6¾d.; condenser, 7¾d.; brazed brass tubes, 8¼d.; rolled brass, 6¼d.; brass wire, 6¼d.; brass turning rods, 6¾d.; yellow metal, 6d. to 6¼d. per lb. Sheet lead, £16 to £16 5s. per ton. English tin ingots, £201 to £202 per ton.

The Lancashire Coal Trade.

There was practically nothing done on the local Coal Exchange on Tuesday. Quotations, however, were fairly steady as follow:—Best Lancashire for domestic purposes, 14s. 2d. to 15s. 2d.; seconds, 12s. 2d. to 13s. 2d.; common, 9s. 6d. to 10s. 8d.; best burgy, 9s 9d. to 10s. 6d.; round furnace coal, 11s. to 11s. 6d.; best slack, 8s. 11d. to 9s. 5d.; medium, 8s. 5d; common, 6s. to 7s., at the pit. Coal for shipping and bunkering purposes, screened, 9s. 9d. to 10s. 6d.; unscreened, 9s. 3d. to 9s. 9d., delivered Manchester Ship Canal.

The Engineering Trades.

The attendance of representatives of the various local engineering trades on 'Change on Tuesday last was below the average. The thinness may be set down to two main causes, the chief of which is the holiday spirit which pervades business circles for some days after Whitsuntide The other cause is the slackness which still characterises several branches of the trade, namely, the textile machinery makers and steam engine and boilermakers. Very pessimistic views are held in these trades. The causes of the bad times are, however, entirely different. The textile machinists are feeling the effects of the boom in cotton mill building which existed a few years ago; but boilermakers, owing to excessive competition, have for some time been occupied in the foolish policy of cutting prices to an extent which is almost akin to suicide. How long is this policy going to last?

Labour Troubles in the Wool-combing Industry.

A strike in the Bradford wool-combing industry seems almost certain unless there if a speedy change in the attitude of the men. The men's officials have delivered an ultimatum to the effect that unless the demand for a five per cent. advance in wages and a minimum of 24s. per week for night workers are granted by to-day (Thursday) the members of the Woolcombers' Union, who number about 10,000, will cease work. The members of the Employers' Federation, on the other hand, affirm that the state of trade and the inequality of wages do not warrant such an advance. The employers also complain that the union has no effective control over the workers.

A Petroleum Spring at Leigh.

A petroleum spring is said to have been discovered in a pit at Leigh, and a large quantity of oil has been obtained. Whether, however, it will be of a permanent nature remains to be seen, for oil has previously been found in Lancashire, although in small quantities.

Ironfounders' Society.

At the conference of the above society held in Manchester last week, presided over by Mr. A. Henderson, it was decided only to make such changes in the society's financial position as are rendered necessary by the new scheme of classification adopted by the conference, or by the amalgamation of the moulders' unions approved by the society, or as the result of the Friendly Society of Ironfounders' organisation becoming an approved society under the National Insurance scheme. A scheme was approved for the arrangement of permanent organisers at a salary of £150 per annum and expenses. The society will be divided into two districts, and the organisers are to be placed in these districts under the control of the executive council.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is no change to note in the general condition of the hematite pig iron trade of this district; certainly no change for the better. There is only a limited amount of business being done, for consumers are only placing contracts sufficient to cover their immediate wants. The orders now held represent a good tonnage of iron, but more metal is being produced in some cases than can readily be disposed of. There is a steady demand on home and overseas account of certain sorts of special iron, and two or three makers are laying themselves out for this class of trade. Prices are unchanged, and those quoted are, to a great extent, nominal. Mixed numbers of Bessemer iron are quoted at 64s. per ton net f.o.b., and special kinds of iron as high as 70s per ton net. Warrants are idle at 62s. per ton net cash. The stores of warrant iron are down a few tons to 40,560 tons.

Iron Ore.

The iron ore trade is fairly well employed throughout the district. In addition to the local business doing, raisers are still selling ore out of the district, and Scotch smelters are obtaining good supplies. Prices are about the same, with good average sorts quoted at from 10s. to 12s., and the best ores are at the recently reduced figure of 19s. 6d. per ton net at mines. For best qualities there is always a good brisk demand, whether it be Hodbarrow or Road Head sorts. For Spanish qualities of ore there is a steady request, but the cargoes arriving are not numerous at present, nor have they been for some time past. The current rate is 20s. per ton delivered for best qualities.

Steel.

In the steel trade the activity is not so marked. There is only a moderate demand for steel rails either on home, colonial, or foreign account, and at Barrow the output is less than of late, the mills only working part of the week. Heavy sections of rails are quoted at £5 12s. 6d. per ton. Light rails command a very poor sale, and little is offering in heavy tram sections. For steel shipbuilding material there is a steady demand on the part of local builders as well as those in various parts of the country, but there is still nothing being done at the Barrow plate mills, and nothing is likely to be done at present prices, which manufacturers state are unremunerative. For other steel sections there is a quiet demand.

Shipbuilding and Engineering.

Vickers Limited will shortly launch from their Barrow yard a cruiser for the Chinese government. The work of engining and completing the Princess Royal is well in hand, and a little army of men can be seen pushing the job on. The floating dock for Aberdeen is not yet finished, but will be shortly. All the departments are busily employed.

Shipments.

The shipments of pig iron last week reached 3762 tons, and steel 2732 tons, a total of 6494 tons, and a decrease of 12,767 tons on the week. The shipments of pig iron and steel this year stand now at 236,967 tons, a decline of 78,901 tons.

Fuel.

There is only a quiet demand for coal, and good steam sorts are quoted at from 11s. to 16s. per ton delivered. East Coast coke is in steady but quiet demand at 22s. per ton delivered.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

General Conditions.

As the result of a conference between the employers' and moulders' representatives the application for an increase of wages by 1s. per week to 42s. has been granted, with liberty to reopen the question on six months' notice. This concession has naturally strengthened the opinion that employment in Sheffield is very good, for the moulders' wages are now restored to the maximum ruling during the recent boom period. Inquiries amongst manufacturers, however, show that while the foundries are working well, the orders received, apart from the Government contracts booked some time ago, are of a hand-to-mouth character. But the chief complaint is as regards the meagre margin of profit owing to the keen competition prevailing at the present time. The armament departments are still fully occupied, owing to the greater labour required in the finishing stages compared with what was the case only a few years ago. This work is of such a prolonged character that the local firms could hardly do with any additional orders of this nature at the present moment. In other directions there is to be noted a fair number of small orders, but there are not many new inquiries of any importance. Consequently the majority of local steel works, while fairly busy in general lines, are unable to see their way far ahead. There is a fair amount of work on hand for shipbuilders in forgings and special castings. It is too early yet to say whether the autumn is likely to bring about a revival, but most manufacturers are hopeful of an improvement, provided no labour disputes arise.

The Coal Trade.

The present condition of the coal trade is rather flat, but it is due more to temporary causes than to any real subsidence of the demand. There is not much being done in shipping, and the keen competition from the North-East is a disturbing factor. Despite this, prices of best hards are maintained at 8s. 6d. to 8s. 9d. per ton at the pits. The firmness of prices is undoubtedly due to the better industrial demand and to the holidays in the coalfield being more numerous than usual, for these have enabled stocks to be got rid of, while it is likely that many pits will set down for the whole of Coronation week. It is stated on good authority that early in the year an attempt was made by several large buyers to "bear" the market, a considerable tonnage of coal being sold, and these dealers have now to buy on the open market at higher prices.

Gas Coal.

There is more business passing in shipments of gas coal, and a good number of inquiries is in the market for tenders. It is expected that the bulk of the business will have been arranged by the end of this month.

Slacks.

Owing to the restricted output at house coal pits, the shortage of small fuel is keenly felt. So far as manufacturing slacks are concerned, the market is very steady. There is no surplus tonnage on offer. Values are steady. Best washed smalls, 5s. 6d. to 6s.; best hard slacks, 5s. 6d. to 5s. 9d.; seconds 4s. to 4s. 3d.

House Coal.

Current business in house coals is not the usual low summer level. In most cases merchants have fallen further in arrears regarding contract supplies, although here and there orders are coming in more freely as the result of the chillier weather. The risk of incurring siding rent charges is against any speculation by merchants, and the special lots on offer are not in eager request.

Pig Iron.

Although business is very quiet, a firmer and more cheerful tone is noticeable in the pig iron trade, due to the feeling that prices have touched bottom. Officially prices are unchanged, and little is heard of any attempt to undersell makers. The position of scrap remains unchanged, there being little or no demand for it. Quotations:—Lincolnshire, No. 3 foundry, 50s. 6d.; ditto, forge, mottled and white, 49s 6d.; ditto basic, 52s.; Derby-hire foundry, 50s. to 51s; ditto forge, 48s to 49s. 6d., all per ton net delivered Sheffield or Rotherham. East Coast hematite mixed numbers, 69s. net.

The Steel Trades.

Outside the heavy armament branches, undoubtedly the most active section of the steel trades is that connected with tools and steel for agricultural purposes, and the present season is likely to be the best ever experienced in Sheffield. The season shipment of sheep shears to Australia is eminently satisfactory. File makers are fairly busy, and shipbuilders are larger consumers. The local rolling mills have a considerable amount of work booked. Wagon builders are fairly busy.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

ON the whole business in the Cleveland pig iron trade has this week been somewhat more buoyant than for a considerable time, and generally there has sprung up a more cheerful tone, as it now seems to be believed that production and demand have become equalised, and that the pressure to sell will not be so great as it has been. Prospects are more favourable, and there is reason to suppose that the lowest in prices has been experienced. Nevertheless, consumers are still rather slow about anticipating requirements, and where they buy it is for delivery only a very short time ahead. The curtailment of stocks in Connal's store and the decrease in the stocks held by the makers renders the position of the producers more favourable than for several months, but unfortunately the operations of speculators in warrants to some extent counteract the good influences that are appearing. The price of No. 3 Cleveland G.M.B. pig iron for prompt f.o.b. delivery has this week been as high as 46s. 7½d. per ton, but on Wednesday there were again sellers at 46s. 6d., with No. 1 at 50s., Nos. 4 foundry and 4 forge at 46s., and mottled and white at 45s. 9d. For delivery next month 6d. per ton more was quoted, and for delivery up to the end of August 1s. more. There will be a curtailment of production next week, when the furnaces will be stopped on Thursday all day for the Coronation, but at the same time the consumption will be curtailed generally for three days, so that the stoppage of the furnaces will not mend matters. Nevertheless, for some time there will be a restricted output of No. 3, as it is expected that for some time after the stoppage the furnaces will not be working so well as they have been lately.

Hematite Pig Iron.

The East Coast hematite pig iron trade is steady, and the outlook is good, for all the steel departments which are consumers of hematite iron are very well employed, and are likely to be so for this year and the greater part of the first half of 1912 if not longer. Makers of hematite iron are not affected by the fluctuations of warrants, their prices being fixed by themselves and the consumers, and the speculator does not step in and do the lion's share as he does in connection with Cleveland iron. There are no East Coast hematite iron warrants with which the speculator can operate, and any stock that is held is in the makers' yards. Hematite iron is held by second-hands, but it is in the makers' yards, and it is a good number of years since producers allowed hematite iron to be lodged in the public stores. It is sold on the understanding that it is not sent there. Quotations for hematite iron in this district have moved very little, and show a great contrast to the state of affairs with respect to Cleveland pig iron, the prices of which change almost every day, at times because some one has bought a few hundred tons of warrants which he does not want from some one who has not got them. Mixed numbers of East Coast hematite pig iron have this week been maintained by makers at 62s. per ton for delivery over the next two or three months, but small lots have been forthcoming for immediate delivery from merchants and one or two of the producers at 61s. 6d. per ton.

Ironmaking Materials.

It cannot be reported that there have been any sales of Rubio or other foreign ore for some considerable time; buying, in fact, is at a complete standstill, and consumers can continue their policy of holding off for some time yet, as there are heavy stocks of ore at most of the works, and besides this the ironmasters have contracts arranged which will carry them generally over the remainder of the year. They will not, therefore, pay anything like the figures which merchants are quoting—20s. per ton for delivery c.i.f., that being, therefore, a really nominal price. Merchants cannot afford to quote less, however, when the Spanish mineowners keep up their rates. A sale at less was reported, but it was in special circumstances, and could not be accepted as a criterion of what could be done in the case of regular contracts. Furnace coke is still in larger supply than demand, but prices are not quite so weak as they were last week, though they are not quotably higher; in fact, consumers have no difficulty in getting all they require at 14s. 6d. per ton delivered at Middlesbrough works, which is about the lowest figure that has ruled for several years.

The Coronation Holidays.

It has been arranged at most of the pig iron making establishments in this district that the furnaces shall cease operations for twenty-four hours next Thursday, and the same procedure will be followed at the ironstone mines and most of the collieries. Nearly all the finished iron and steel works will be laid off Thursday, Friday, and Saturday. They, however, were kept in full operation on Whit Monday, in order that the men might have a longer stoppage next week. One of the leading steel works will stop for the Thursday only. Foundries will mostly be closed three days, as will some of the shipyards and engineering establishments.

Stocks of Pig Iron.

The return of stock of Cleveland pig iron in Connal's public stores is steadily becoming more favourable for the sellers, and should have a good influence on the market. Decreases are more often reported than increases. One feature this week was particularly worth notice, and was one of the main influences in bringing about an advance of prices. It has for a long time been noticed each Monday that stocks have increased heavily—from one to two thousand tons—but for Monday this week there was actually a decrease of 1112 tons. That served to impart more confidence among traders, and there was more disposition to buy. On Wednesday the stock held was 592,825 tons, a decrease for the month of 1175 tons. Of this stock 535,917 tons were of No. 3 quality. It is reported from this change in the stock returns that the over production of pig iron, which has been going on so long, has practically ceased.

Exports of Pig Iron.

The exports of pig iron from the Cleveland district are not so good as they were last month, but that was looked for. June is usually a quieter period than May as far as regards shipments. The quantity exported up to 14th was 41,128 tons, as compared with 57,029 tons last month, 54,416 tons in June, 1910, and 51,602 tons in June, 1909, all to 14th. Increased deliveries are expected to Canada, Italy, and Russia, to the latter country on account of the temporary suspension of the import duties, which the Government there have decided upon owing to the scarcity of pig iron, the native ironworks being quite unable to satisfy the country's demands at present. Good shipments may be looked for during the next fortnight if the threatened strike of seamen does not become a reality.

Manufactured Iron and Steel.

More activity is reported in the demand for manufactured iron and steel than for some time, and the outlook is certainly more encouraging. Manufacturers are generally well off for orders, and can keep their mills in full operation. Works which were a few weeks ago running short time are in full operation again, and large exports of steel are once more being made, especially to India and Japan. The improvement in the steel rail business is very welcome, and the manufacturers are able to keep up the price of heavy rails at £5 12s. 6d per ton net f.o.b. The plate and angle manufacturers are very much pressed for deliveries, and there is likely to be a demand for all that can be made up to the end of the year, and, indeed, for well into next year. Less than £6 15s., less 2½ per cent. f.o.t., will not be taken for steel ship

plates, and £6 12s. 6d., less 2½ per cent. for iron ship plates, while steel ship angles are at £6 7s. 6d. and iron ship angles at £7, both less 2½ per cent. f.o.t. Hoops, strips, sheets, and joists are in very fair request. Exports of galvanised and corrugated steel sheets are brisk, and manufacturers are able to get £10 15s., less 4 per cent. f.o.t. for 24-gauge.

Shipbuilding.

The construction of new shipping was never so extensive in this district as it is at present, and builders are supplied with work which will keep their yards fully going not only this year, but the greater part of next. The Middle Docks Company, South Shields, with a view to extensions which may be necessary, has acquired the business premises of J. T. Eltringham and Co., known as the Stone Quay Ship and Boiler Building and Engineering Works, which adjoin its premises. The additional site acquired has a frontage of 750ft. to the Tyne, and an area of 4¾ acres. The Middle Docks Company has now three dry docks, one of which, 460ft. long and 62ft 6in. in width, with a depth of water of 23ft. 6in. over the sill at high water, was completed in 1909. Messrs. Eltringham have become the lessees of their present premises, and continue the business which they formerly carried on at Stone Quay.

Shipbuilding Labour Disputes.

The dispute between the Shipwrights' Society and the Boilermakers' Society at Short Brothers yard at Pillion is not yet settled. The boilermakers put all the blame on the shoulders of the Shipwrights' Society. The boilermakers say they asked the shipwrights not to blackleg the members of their (the boilermakers') society employed in Messrs. Short's yard, but this they refused. They further affirm that Messrs. Short locked out the members of the Boilermakers' Society because the Shipwright's Society intimated that if a member of the Boilermakers' Society were allowed in the yard they would all walk out. Furthermore, it is asserted that the Shipwrights' Society passed a resolution claiming for themselves the whole construction of ships, no matter of what material they are built. The boilermakers' organisation state that they will never admit the Associated Shipwrights' claim to do iron and steel shipbuilding, that being the legitimate work of the members of the Boilermakers' Association. The shipwrights point out that 70 per cent. to 80 per cent. of the shipwrights are employed exclusively in iron and steel in constructing vessels, and they deny that the shipwrights should simply work in wood. The crux of the whole dispute is that some members of the Shipwrights' Society who had received assistance during the depression allowed themselves to fall into arrears in their contributions, and, when times mended, were asked to pay up. They objected, and instead they joined the Boilermakers' Society to avoid their responsibilities to the Shipwrights' Society. To this the latter organisation naturally objected, and Messrs. Short Brothers locked out the men who had joined the boilermakers, as they only recognised the Shipwrights' Society. A conference of representatives of the Boilermakers' Society, the Shipwrights' Society, and the General Federation of Trades Unions has been held at Newcastle on the subject, and a full report is to be presented to the full management committee, which will seek some solution of the whole trouble.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Pig Iron Warrant Market.

THE Glasgow pig iron warrant market has been quiet this week, operators showing little disposition for business. Holiday influences, past and prospective, are reducing speculative operations. Increasing outputs of iron on the Continent and continued unsatisfactory advices from the United States have a discouraging effect. On the other hand, there has been a disposition to regard prices as quite moderate from the point of view of the consumer and shipper, although the purchases made are limited in extent. It is understood that the market is not receiving much support from the South just now, but prices of warrants nevertheless have had an upward tendency in the last few days. Business has been done in Cleveland warrants from 46s. to 46s. 4d. cash, 46s. 2d. to 46s. 7d. one month, and at 46s. 10d. three months. Sales have also taken place at 46s. 5½d. for delivery on 11th July and 46s. 6d. thirteen days.

The Scotch Pig Iron Trade.

Two furnaces have been put out of blast in Scotland, making the number in operation 83, compared with 85 at this time last year. Home requirements at the moment are on a moderate scale, and while the past week's shipments abroad have been considerably better than usual, the inquiry is reported quiet. A quantity of Scotch iron has been sold on Russian account, and it is hoped this outlet will for some time be of advantage to the trade; but shippers have learnt with somewhat mixed feelings that they are not unlikely to have to compete with America at Mediterranean ports. Prices of Scotch ordinary and special brands have been steady. Govan and Monkland are quoted f.a.s. at Glasgow:—Nos. 1, 56s.; Nos. 3, 55s.; Carnbroe, No. 1, 60s.; No. 3, 56s.; Clyde, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Gartsherrie and Calder, Nos. 1, 61s.; Nos. 3, 56s.; Summerlee and Langloan, Nos. 1, 63s.; Nos. 3, 58s.; Coltness, No. 1, 82s. 6d.; No. 3, 58s.; Eglinton, at Ardrossan or Troon, No. 1, 56s.; No. 3, 55s.; Glengarnock, at Ardrossan, No. 1, 64s.; No. 3, 59s.; Dalmellington, at Ayr, No. 1, 57s.; No. 3, 55s.; Shotts, at Leith, No. 1, 62s.; No. 3, 57s. 6d.; Carron, at Grangemouth, No. 1, 63s.; No. 3, 58s. per ton. The past week's Scotch pig iron shipments amounted to 4251 tons foreign and 2095 coastwise, the total of 6356 comparing with 4996 in the corresponding week. Cleveland pig iron is finding a good market in Scotland, the imports showing an increase of 11,531 tons since the beginning of the year.

Hematite Iron and Steel.

The market for hematite pig iron continues quiet. Inquiry for Cumberland warrants has led to hardly any business, and the quotation is 62s. 3d. per ton f.o.b. Cumberland ports. Steady deliveries of Scotch hematite are being made to steel makers, but the fresh demand is only moderate. Merchants quote 65s. to 66s. per ton for Scotch hematite for West of Scotland delivery. The steel works are turning out a large amount of material, but they have capacity for producing considerably more. Orders come to hand for shipbuilding steel in fair quantity, but there is no great pressure for delivery except in special cases. A large business has been done in boiler plates, but some makers report that the demand for ship plates is not quite so good as it was a short time ago. Competition in angles has been keen, and English and Welsh makers have had a considerable proportion of the Clyde business. Angles are quoted £6 10s., ship plates £6 17s. 6d., boiler plates £7 12s. 6d., bars, £7 10s., and sheets £7 7s. 6d. per ton, all less the usual 5 per cent. discount for delivery in the Clyde district.

Malleable Iron and Engineering.

Business has been quiet in the finished iron department. Low prices led to a considerable accession of orders recently, and these have kept the works in tolerable employment, but the outlook is not quite so cheering as could be desired. Best bars are quoted £6 17s. 6d., and crown bars £6 10s. for Glasgow delivery, but common bars are considerably lower for export. Some branches of the engineering trade, such as the marine department, have been passing through a period of considerable activity, but in other connections there is room for improvement. Locomotive engineers have had foreign orders in hand under conditions of extra rapid production, but beyond these they do not appear to see very far ahead.

The Coal Trade.

While the volume of business in the coal trade is about normal, as far as shipments are concerned, heavy outputs and much reduced household consumption owing to long-continued warm weather, has produced a state of things which is occasioning some anxiety to coalmasters, who have been conferring together with the object of discovering some method of reducing production, and so obviating a further decline in prices. It is feared that a combination for this purpose will be found impracticable.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THE holidays had the usual effect of rendering slack times still more so, and fresh transactions were rare. The impression on 'Change was favourable to the retention of quotations. It was argued that with the coming on of the Coronation holidays supplies would lessen and tonnages not improve. Admiralty coals continued to be quoted high, and it was noticed that the market showed a stronger indication to be firm, and even Monmouthshire large coals showed a slight easiness. House coals and bituminous generally were easy, and the summer heat lessened even the usual quiet trade that is done locally. Business in small coal was irregular, and cargo smalls were only about 9s.

Latest Quotations, Cardiff.

The disposition amongst the colliers on strike is to favour a general, or what they choose to call a national strike. At the Saturday conference of the South Wales Miners' Federation it was decided to present a demand to the Miners' Federation of Great Britain that Rule 20 should be enforced, with the view of securing a definite minimum wage throughout the country; or, in the alternative, with the view of carrying out a new policy with regard to workers in abnormal places, and the lower paid day wage men. This, an able critic on the situation remarks, is not likely to be followed. All the coalfields in the country are working under agreements, which have a considerable term to run. No action can be taken by the National Federation in the direction demanded by the conference of the Cardiff meeting without destroying their agreements and placing the coal trade of the country in chaos and ruin. It remains to be seen if the experienced and trustworthy leaders both of the National and of South Wales are to be overborne by the irresponsible section of the colliers, who are regrettably, it may be added, more bent on making opposition speeches than in wise debate and thoughtful action.

Latest.

It was announced in Cardiff on Wednesday that the Miners' Federation of Great Britain, at the conference in London, passed a resolution stating that, in the opinion of the conference, the object sought by the South Wales colliers is secured in the proposed terms of settlement signed on behalf of the workmen by E. Edwards, T. Ashton, W. Abraham ("Mabon"), and Mr. T. Richards, and now agree to accept no further responsibility with reference to the dispute. This practically ends the strike, after nine months' bitter action and the almost total depletion of the colliers' funds. The action of the English and Scotch section is unanimous. It only remains to be seen whether the Welsh contingent will acquiesce or sunder connection with the others and pursue a blind and ruinous policy, deprived, as they must be, not only of funds, but of the guidance of the older and more thoughtful of their fellows. When the news arrived at Cardiff it was too late to get definite opinion as to the course to be pursued, but the end has come. Latest quotations are:—Best large steam, 18s. 3d. to 18s. 9d.; best seconds, 16s. 9d. to 17s. 6d.; ordinaries, 16s. to 16s. 6d.; best drys, 16s. to 16s. 9d.; ordinary drys, 14s. 9d. to 15s. 6d.; best washed nuts, 14s. 6d. to 15s.; seconds, 13s. 6d. to 14s.; best washed peas, 12s. 6d. to 13s. 6d.; seconds, 11s. to 12s.; best bunker smalls, 10s. 6d. to 11s.; best ordinaries, 10s. 3d. to 10s. 6d.; cargo smalls, 9s. to 9s. 3d.; inferior, 8s. to 8s. 6d.; best Monmouthshire black vein, 15s. 9d. to 16s. 3d.; ordinary Western Valleys, 15s. 3d. to 15s. 6d.; best Eastern Valleys, 14s. 3d. to 14s. 9d.; seconds, 14s. to 14s. 3d. Bituminous:—Very best households, 17s. to 18s.; best ordinaries, 14s. 6d. to 16s. 6d.; No. 3 Rhondda, 17s. to 17s. 6d.; brush, 13s. 3d. to 13s. 9d.; smalls, 16s. 6d. to 16s. 9d.; No. 2 Rhondda, 12s. to 12s. 3d.; through, 10s. 3d. to 10s. 6d.; smalls, 8s. to 8s. 6d. Patent fuel, 16s. 9d. to 17s. 6d. Coke: Special foundry, 24s. to 25s.; foundry, 18s. to 20s. 6d.; furnace, 16s. to 17s. Pitwood, 18s. to 18s. 6d. Coal and patent fuel 30 days, cash, less 2½.

Newport, Mon., Coals.

Steam coal trade not very strong; tonnage backwards; sellers firm in quotation. Shipments of coal last week, 51,805 tons foreign; coastwise, 11,652 tons; action of colliers and seamen causing a waiting policy. Latest quotations:—Very best black vein, 15s. 6d. to 16s.; Western Valleys, 15s. to 15s. 3d.; Eastern, 14s. to 14s. 3d.; other kinds, 13s. 6d. to 13s. 9d.; best smalls, 8s. 6d. to 8s. 9d.; seconds, 8s. to 8s. 6d.; inferiors, 7s. 9d. to 8s. Bituminous: Best household, 15s. 6d. to 16s. 6d.; seconds, 14s. to 15s. Patent fuel, 16s. to 17s. Coke: Foundry, 18s. to 20s.; furnace, 16s. to 17s. Pitwood, 18s. to 18s. 6d.

Swansea Coals.

Last week shipments were 52,592 tons to foreign; patent fuel 2800 tons; holidays interfered. This week trade was firmer. Swansea Valley, large, much better; slight advance, but red vein weak. Latest: Best malting, 21s. to 23s. net; seconds, 17s. 6d. to 19s. 6d. net; big vein, 15s. 6d. to 17s. 6d., less 2½; red vein, 11s. 6d. to 13s. 6d., less 2½; machine-made cobbles, 20s. 6d. to 22s. 6d. net; Paris nuts, 22s. to 23s. 6d. net; French nuts, 21s. to 23s. 6d. net; German nuts, 21s. 6d. to 23s. net; beans, 19s. 6d. to 21s. 6d. net; machine-made large peas, 10s. 6d. to 11s. 6d. net; rubbly culm, 7s. to 7s. 3d., less 2½; duff, 3s. 3d. to 3s. 9d. net. Steam coal: Best large, 17s. 9d. to 18s. 9d.; seconds, 14s. 3d. to 15s. 3d.; bunkers, 10s. 6d. to 11s. 6d.; small, 7s. 6d. to 8s. 6d., all less 2½. Bituminous: No. 3 Rhondda, 17s. 6d. to 18s. 6d.; through, 15s. 6d. to 16s.; small, 10s. 9d. to 11s. 6d., all less 2½. Patent fuel, 14s. 6d. to 15s., less 2½.

Iron and Steel.

The holidays affected the iron making generally in the district. The mills at Dowlais ceased operations, but the furnaces were kept going. The No. 3 furnace, which has continued for some time, has now been blown out, and will forthwith go into repair. Little iron movement at present. Dowlais has been receiving iron ore, and Ebbw Vale had a cargo this week from Algiers. On the Metal Exchange, Swansea, the following quotations were given this week:—Pig iron: Hematite, mixed numbers, 62s. 3d. cash, 62s. 6d. month; Middlesbrough, 46s. 3½d. cash, 46s. 6½d. month; Scotch, 52s. 4½d. cash, 52s. 7½d. month; Welsh hematite, 67s. 6d. to 68s. delivered; East Coast hematite, 62s. 6d. to 67s. 6d. c.i.f.; West Coast, 66s. 6d. to 67s. 6d. c.i.f. Steel bars: Siemens, £5; Bessemer, £4 17s. 6d.; iron ore, c.i.f. Cardiff and Newport, 19s. to 20s., on the basis of 50 per cent. iron.

Tin-plate.

In various parts of the district the millmen and tin-plate workers generally complained greatly of the heat, which was remarked as quite tropical. This interfered with make. The Swansea Central reported the quantity received from the works as 78,713 boxes, and shipments 100,536 boxes. Stocks now total 206,047 boxes in vans and warehouses. Tin-plate continues in good demand, and large clearances continue to be made in particular to Eastern markets. Latest:—The improved tone in the market is maintained, and a tolerable amount of business is being done. Makers' quotations are as follows: Bessemer cokes, 13s. 9d. to 13s. 10½d.; C.A. roofing sheets, 30 g., £9 to £9 5s. per ton; finished black plates, £11 10s. per ton; galvanised sheets, 24 g., £10 15s.; block tin, cash, £229 15s.; £163 10s. three months. Copper, £56 3s. 9d. cash, £56 15s. three months. Lead: £13 15s., English; Spanish, £13 5s.; spelter, £24 10s. Silver, 24 1/16d. per oz.

Ebbw Vale Workmen.

The result of an interview between the workmen of Ebbw Vale and the general manager has been the formation of a committee deputed to wait upon the Board of Trade and the Chancellor of the Exchequer to see if any measure of aid can be given. The workmen say that if anyone can carry on the works successfully it is Mr. Mills, the general manager, but the dumping of foreign steel produced at less than cost prevents free competition in the iron and steel industry. At the general meeting of the company in London on Tuesday the chairman stated that the works were not stopped because of want of work. The world's requirements of iron and steel were greater than ever; nor was it a question of economy in running the works, for they had good plant, a good organisation, good workmen, and a plentiful supply of fuel.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, May 7th.

NOTWITHSTANDING the general shading of prices in structural material and plates, buyers of large quantities of material, estimated at as much as 200,000 tons, are awaiting further developments, though it is not easy to see what developments they expect. A rather unsettled feeling prevails in all channels of the steel industry. Some well posted authorities look for a very heavy compensating demand before the close of the month. The inquiries now under consideration cover requirements for bridge and constructional material in all sections of the country. The requirements for this city and vicinity on which final action is almost daily awaited amounts to about 60,000 tons. There are also pending orders for structural material for export, among which there are 2500 tons for Government buildings at Pearl Harbour, Sandwich Islands. The Canadian Car and Foundry Company is in the market for 3000 tons of low phosphorus iron, on which English quotations are 21 dols. Alabama iron is offered at the furnaces at 10.50 dols. The present inactivity was liable to terminate unexpectedly in the placing of large orders at possible concessions at current rates. Merchant steel for agricultural implements has been quiet all the week, and sales of bar iron have dropped off, because of the uncertainty existing as to inside prices. The independents are on the alert for every possible order, and interesting developments are awaited. Notwithstanding the unfavourable trade conditions of the past year, a large amount of new capacity has been added for the production of both crude and finished material. The Chilian Government has contracted for two submarine vessels to be built at Seattle. Orders for steel cars have begun to pick up again, the latest large order being for 1000 gondola cars for the Atchison Railroad. They will be made by the Pressed Steel Car Company. The Canadian Pacific has also ordered 500 underframe box cars, which will be made by the same company. The Pennsylvania Company has ordered 41 all-steel coaches from the same company. The Norfolk and Western is building eleven 12-wheeled locomotives and the Missouri, Kansas and Texas will order this week 108 freight cars. The makers of machinery have been receiving more encouraging inquiries since the first of June than for several months, the largest recent inquiry being for 75,000 dols. worth for tools and equipment for the New York Central Railroad. Sugar plantations in Cuba and various parts of the West Indies are calling for a good deal of special machinery used in sugar cultivation and manufacture. The copper interests are anticipating a general improvement in the industries using copper in this country and believe the low prices of the past few months will disappear. Electrolytic is quoted at 12½, and May deliveries are a little in excess of April.

CATALOGUES.

THE BRITISH ALUMINIUM COMPANY, 109, Queen Victoria-street, E.C.—A circular to hand from this company has reference to the physical, mechanical, and electrical properties of aluminium.

THE STERLING TELEPHONE AND ELECTRIC COMPANY, Limited, 200, Upper Thames-street, London, E.C.—Pamphlet No. 182 has reached us. It has reference to "Sterling" telephones of various types, and gives prices and other particulars of interest to buyers.

THOMAS RYDER AND SON, Turner Bridge Ironworks, Bolton.—Catalogue No. 20 has reference to "Ryder" massive high-speed lathes, and contains a general specification of the firm's sliding, surfacing and screw-cutting lathes. Various types are illustrated, and prices, dimensions, code words, &c., are given.

SIEMENS BROTHERS AND CO., Limited, Caxton House, Westminster, S.W.—A very interesting pamphlet on "Wireless Telegraphy" has been sent to us by this firm. Anticipating that in the near future there will be a large field for business in wireless telegraphic apparatus, this company has obtained the rights in England of a system well established—*i.e.*, the Telefunken system, introduced by the Gesellschaft für Drahtlose Telegraphie, of Berlin. The pamphlet fully describes this system, and illustrates all the apparatus used. It is a publication which cannot fail to interest those connected with wireless telegraphy.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. E. KILBURN SCOTT has been appointed Lecturer in Electrical Design at University College for the session 1911-12, in succession to Mr. H. M. Hobart, resigned.

SIEMENS BROS. DYNAMO WORKS, Limited, request us to state that for the convenience of customers engaged in illumination work, their London Stores, 39, Upper Thames-street, will be open till 11 p.m. on Tuesday, the 20th, and all night on Wednesday, the 21st of this month. Telephone, 8270 Wall.

MR. E. C. GOWING, formerly works manager with the late John Abbot and Co., Limited, Park Works, Gateshead-on-Tyne, and for some time general manager of John Bellamy, Limited, London, has resigned his position with the latter firm to take over the works management of Simms Magneto Company, Limited.

IN connection with the organisation of the new Department of Heating and Ventilating Engineering at University College, towards which the London County Council have made a grant in aid, Mr. Arthur Henry Barker, vice-president of the Institution of Heating and Ventilating Engineers, has been appointed lecturer for the session 1911-12.

CONTRACT.—The Govan Combination Parish Council has accepted the tender of Meldrum Bros., Limited, Timperley, Manchester, for the erection of a refuse destructor at the poorhouse.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

THE position of the iron and steel market is good so far as employment is concerned, plenty of fresh orders having come in during the week; prices, however, are unremunerative. The mills in many instances take in orders at ridiculously low rates, just to keep up a brisk activity. In some branches, however, both prices and the amount of fresh work secured are satisfactory. The machine and engineering departments, for instance, are well supplied with contracts at profitable prices, and prospects may be considered fair.

The Iron Market in Silesia.

A regular and satisfactory business was done last week, both in raw and in manufactured iron, prices showing a good deal of firmness. Exports remain moderate.

List Prices.

The following are the current list quotations per ton free at works:—Raw spathose iron ore, M. 11.60; roasted ditto, M. 16.50; Nassau red iron ore, M. 14, net at mines; spiegeleisen, 10 to 12 per cent. grade, M. 63 to M. 65; white forge pig, M. 59 to M. 60; iron for steel making, Siegerland quality, M. 59 to M. 60; Rhenish-Westphalian sorts, M. 62 to M. 63; German Bessemer, M. 70; basic, free Luxemburg, M. 52 to M. 53; Luxemburg forge pig, free Luxemburg, M. 48 to M. 50; Luxemburg foundry pig, No. 3, free Luxemburg, M. 50 to M. 52; German foundry pig, No. 1, M. 66; No. 3, M. 64; German hematite, M. 70; bars in basic, M. 101 to M. 105; iron bars, M. 130 to M. 133; hoops in basic, M. 135 to M. 140; steel plates, M. 122 to M. 124; heavy plates for boiler making purposes, M. 132 to M. 134; sheets, M. 137.50 to M. 142.50; drawn wire in iron or steel, M. 130.

The German Coal Market.

The consumption in engine classes of fuel continues lively as before, both in the Rhenish-Westphalian district and in Silesia. The tone of the coal market generally is satisfactory, and in Silesia this year's deliveries are expected to exceed considerably those of last year. The cokeries especially are in a much better condition than during previous years, the demand rising steadily.

Quiet Trade in Austria-Hungary.

On the whole there was but a limited business transacted in the past week, both raw and finished iron lacking animation. Next week a meeting of the Iron Convention will take place, and a slight reduction in rates for the third quarter is likely to be agreed upon. Foreign, and more especially the German, competition continues to be very keenly felt. The engineering and bridge-building departments are somewhat hard up for work; a final decision regarding the new Danube bridges is eagerly awaited. Demand is about equal to consumption in the Austro-Hungarian coal industry. In the coke trade a marked improvement can be reported owing to a good demand from the inland ironworks, and also in consequence of an increasing export to Russia.

Good Accounts from France.

A favourable development is reported from all departments. The mills have resolved to leave prices unchanged for the present. For merchant iron the Paris retail prices for consumers are 170f. to 175f. p.t., special sorts realising 180f. to 190f. p.t., hoops and girders stand at 200f. p.t., while 3 mm. plates are quoted 200f. to 210f. p.t. Active inquiry is reported for girders and for sheets, while heavy plates and cast iron pipes are a little quieter. Brilliant accounts are given of the motor car industry. The pig iron market is influenced by the dullness that prevails in the neighbouring countries, and also by the heavy imports from England and from Luxemburg-Lorraine. The French coal market is exceedingly firm, and a good business has been done in all classes of engine coal; house fuel is, naturally, in moderate request. During the first quarter of present year 4,321,400 t. coal have been imported, as compared to 3,435,825 t. in the same period the year before. From England 2,584,200 t. were imported, against 2,099,901 t.; from Germany 689,300 t., against 409,585 t. in the same quarter last year. Imports in coke were 625,800 t. for the first quarter of present year, as compared to 529,038 t. in the corresponding period last year, 509,900 t. coming from Germany, against 400,922 t. in 1910.

No Change in Belgium.

There is not much of interest to be told concerning the iron and steel industry. The majority of the blast furnace works have been able to dispose of their output for the next three months, but at very low prices. As a rule sales are effected at 60f. to 61f. p.t. for forge pig, 65f. to 67f. p.t. for basic, and 66.50f. to 68f. p.t. for foundry pig. In spite of steadily increasing output in crude iron, which was 678,000 t. for the first four months of the present year, as compared with 593,000 t. for the same period last year, supplies from abroad are heavy, being 244,000 t. for the first four months, as compared to 224,000 t. in the same period the year before. Export in semi-finished steel, which was very lively in the first quarter, has slackened off a little; during the first four months of the present year 46,693 t. were exported to England, against 262,540 t. in the same period last year. Scrap iron is weak in spite of a rising export. Confidence appears to be increasing in the bar trade, for orders for forward delivery have been secured freely; prices, however, do not get beyond £4 11s. to £4 12s. p.t. for export, and that leaves next to no gain. German competition is exceedingly keen. Rails, girders and plates develop satisfactorily. Coalowners in the Charleroi and Liège district are contemplating opening an office for sale in Paris, for the purpose of regulating prices. The Coke Syndicate resolved to maintain the present prices of 22f. for common blast furnace coke and 25f. to 27f. p.t. for better qualities also during next quarter. Import in German coke increases steadily, rising during the first four months of the present year from 155,000 t. to 215,000 t.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made at the Admiralty:—

Engineer Commanders.—L. R. Croisdale, to the Berwick; E. D. Mallinson, to the Prince George; W. T. Hocken, to the Prince of Wales, additional, for service on staff of Vice-Admiral commanding Atlantic Fleet; W. F. Pamphlett, to the Africa, additional, for service on staff of Vice-Admiral commanding 3rd and 4th Divisions of the Home Fleet.

Engineer Lieutenants.—E. E. Pethick, to the Brilliant; A. E. Everitt, to the Naiad; J. M. Murray, to the Pandora; F. S. Ainsworth, to the Vivid, additional, for the Chelmer, temporary on paying off; G. H. Starr, H. Davies Robinson, F. Howard Lyon, and Charles E. M. Roe have been advanced to the senior list; J. P. Johns and H. A. Slade, to the Victory, supernumerary; F. R. G. Turner and F. V. King, to the Vivid, supernumerary.

Engineer Sub-Lieutenants.—R. G. Parry, to the Vivid; H. F. du M. Hunt, D. J. Hoare, and J. H. Breaks, to the Victory, all supernumerary.

ROYAL NAVAL RESERVE.

Senior Engineer.—W. D. Robertson has been placed on the retired list, with the rank of Chief Engineer.

Engineer.—A. Colquhoun has been placed on the retired list, with the rank of Senior Engineer.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

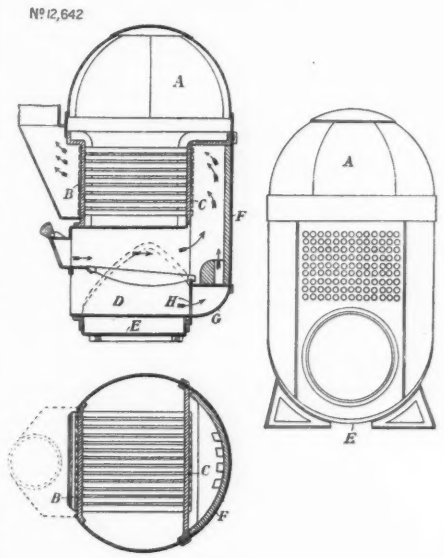
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of the Patent.

STEAM GENERATORS.

12,642. May 24th, 1910.—AN IMPROVED FIRE-TUBE BOILER, *Aktieselskabet Bergens Mekaniske Vaerksted, of Solheimsvigen, Bergen, Norway.*

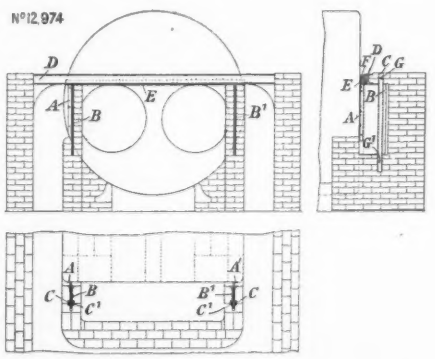
The vertical part of the boiler shell is provided with the tube plates B and C, to which are connected cylindrical portions of a given height corresponding to the size of the steam chamber desired in any particular case. These plates B and C also serve to secure a cylindrical furnace D, and, being made plane, and acting as parts of the shell plate, are braced by the fire tubes and the furnace in such a manner that extra braces are superfluous. The shell plates on each side between the tube plates retain their cylindrical form, while the bottom E of the boiler is also made cylindrical, and has its axis at right angles to the tube plates. The cylindrical parts of the vertical boiler shell are carried down below



the axis of the cylindrical bottom portion, and end at the lines of intersection with the latter, the arrangement of such joint being shown by the dotted lines in the top left-hand engraving. The combustion chamber is constituted by the space between the tube plate C and an iron plate F, lined with fire-brick, and which is curved to conform to the radius of the boiler. This plate is secured at three sides to the shell of the boiler by readily removable clamps, and on the fourth side to a hollow cast iron or sheet iron bracket G, which at the same time serves as a support to the grate and as a fire bridge. The bracket has an opening H into the furnace, through which fresh air is conducted upwards into the combustion chamber through holes in the fire bridge. By graduating the supply of air through the opening a complete combustion of the coal gases can be effected.—*May 24th*, 1911.

12,974. May 28th, 1910.—IMPROVEMENTS IN STEAM BOILERS AND THE LIKE, William Hamer, 82, Crostons-road, Elton, Bury.

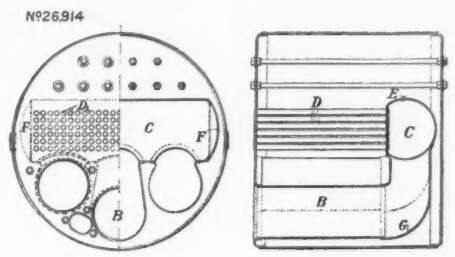
The object of this invention is to increase the efficiency of boilers and to prevent the emission of black smoke from the back end of the boiler into the chimney flue. The channel irons C and C^1 constitute packing parts. These are held together by bolts at the top and bottom as shown at G and G^1, and are built into the



brickwork. These channel irons are packed tightly with a non-combustible packing against the plates B and B^1. D is a girder extending from wall to wall; E represents an angle iron attached to the boiler horizontally. The space between the angle iron E and the girder D is filled with a non-combustible packing F, forming a tight joint by the use of the packing material. A A^1 are angle irons, by which the projecting plates B B^1 are fitted to the end of the boiler.—*May 24th*, 1911.

26,914. November 19th, 1910.—IMPROVEMENTS IN OR RELATING TO BOILERS, James Lees, of "Elsinore," Greenway, Huxton Mount, Essex.

The combustion chamber C is formed so that the same shall be approximately circular in vertical section taken in the direction of the length of the boiler, or the combustion chamber may be formed so that it is completely or approximately spherical when required for a boiler having only one furnace. As shown, the body of the combustion chamber is conveniently, though not necessarily, rolled from a single plate having a lapped joint E, and dished plates F are secured to the ends of the body portion of the combustion chamber. At the same time the end of each furnace flue B adjacent to the combustion chamber is preferably fitted with an elbow piece G, which is also secured to the combustion chamber so that a free path for the furnace gases is thereby provided, while at the same

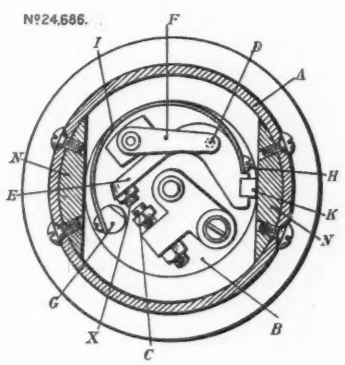


time there will be no sharp corners or angular projections against which the furnace flames may impinge, or the furnace flue may be continued in one piece and have its end adjacent to the combustion chamber flanged outwardly and upwardly so as to gradually sweep into the curve of the combustion chamber.—*May 24th*, 1911.

INTERNAL COMBUSTION ENGINES.

24,686. October 24th, 1910.—IMPROVED INTERRUPTER FOR IGNITION MACHINES, *Robert Bosch, of Hoppenlaustrasse 11-13, Stuttgart, Germany.*

The accompanying engraving shows a vertical section through the common axis of the casing A and disc B. The contact C is fixed, and generally insulated, and is secured to the disc B. A two-armed lever E is pivoted on a pin D on the disc B. A leaf spring F prevents the lever from slipping off the pin. One arm of lever E carries the other contact X, and a spring I, fixed to the

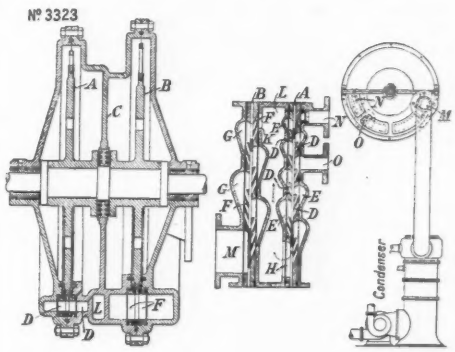


disc B at G and to the other free arm of the lever at H, tends to press continuously the contacts C_1 and X together. When in use the disc B is generally rotated, whilst the casing A is stationary. The interrupter can, however, be driven in the reverse manner. On the outer end of the free arm of the lever E is placed a block K of ebonite, and on the inner periphery of the casing A there are, for example, two cams N, N, which extend so far into the path of the block K that they deflect the lever from the circuit-closing position when the block strikes against the cams.—*May 24th*, 1911.

TURBINES.

3323. February 10th, 1910.—IMPROVEMENTS IN ELASTIC FLUID TURBINES, *George Westinghouse, of Westinghouse Building, Pittsburg, Pennsylvania, U.S.A.*

Two running wheels, A and B, are surrounded by a casing provided with steam packing, through which the shaft passes. The casing is provided with a partition or diaphragm C. The lower half of the casing preferably carries all of the nozzles and collecting chambers. Any number of expansion stages for each of the wheels may be provided, and, for the sake of illustration merely,



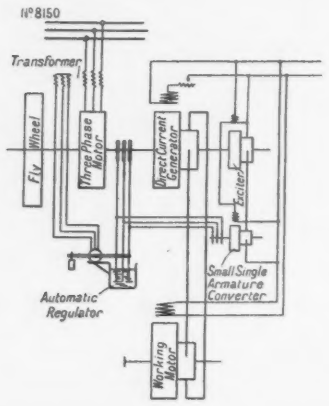
the series of nozzles D for the first or high-pressure wheels and the collecting chambers E, which co-operate with the nozzles, are shown. In the second or low-pressure wheel the series of nozzles F with the co-operating collecting chambers G are shown. The exhaust H of the first wheel is led to the inlet K for the second wheel through passage L, and the exhaust port M of the second wheel is coupled to the condensing apparatus. In addition to the main inlet N, the first wheel is supplied with an overload inlet O for admitting live steam to the collecting chamber of one of the intermediate stages of expansion.—*May 24th*, 1911.

DYNAMOS AND MOTORS.

8150. March 31st, 1911.—IMPROVEMENTS IN ARRANGEMENTS FOR REGULATING THE VOLTAGE OF DIRECT-CURRENT MACHINES RUNNING AT VARIABLE SPEEDS, *the Allgemeine Elektricitäts-Gesellschaft, of Friedrich Karl-Ufer 2-4, Berlin, Germany.*

This invention relates to the regulation of the voltage in a direct-current circuit having its current supplied from a direct-current generator driven at a variable speed by an induction

motor. When the speed of the main converter falls, the slip voltage of the induction motor increases, causing an increase in the voltage of the direct-current side of the small single armature converter, which can be so arranged that the rise in voltage is equal to the decrease of potential of the exciting machine due to its fall of speed, so that the sum of the voltages of the small single armature converter and the exciter remains constant regardless of the variations in the number of revolutions of the converter. It is even possible to cause this total voltage to increase with falling speed, in order to make allowance for the particular decrease in speed of the direct-current generator, particularly in the case when

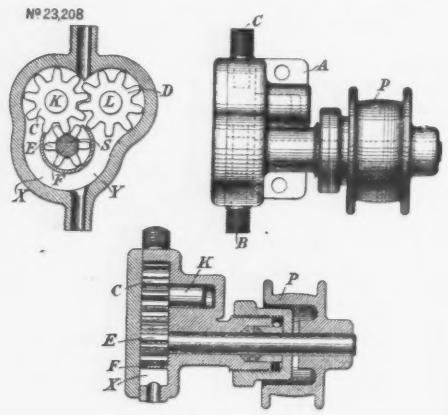


the working motor is excited from a special source of current. The output of the single armature converter varies with the speed of the main converter, and is only slightly affected by the output of the exciter. By over-excitation it may be employed at the same time for phase-compensation for the induction motor. It may also be replaced by a motor generator, whereby its speed, varying with the periodicity of the slip currents, causes a corresponding variation of the direct-current voltage produced by it. The arrangement above described may be employed wherever an induction motor and a direct-current machine are driven together with variable speed, and where for any purpose a direct-current voltage independent of the decrease in speed is necessary.—*May 24th*, 1911.

PUMPING AND BLOWING MACHINERY.

23,208. October 7th, 1910.—IMPROVEMENTS IN ROTARY PUMPS FOR MACHINE TOOLS AND OTHER PURPOSES, the Barton Tool Company, Limited, of Richard-street, Birmingham.

The pump body consists of a cast body part, having a seating A, whereby it may be bolted to the machine frame, an inlet opening B at one side, and at outlet C at the opposite side, the pumping wheels being between the inlet and outlet. The pumping is effected by the rotation of two spur wheels C, D meshing together, and carried on shafts entering bearings on the interior of, but not projecting through, the walls, so that leakage is impossible. In addition to the pumping wheels C, D, and between same and the inlet, a third or driving wheel E is employed, engaging one pump wheel C, the second pump wheel D being driven by the first. Around the driving wheel, extending for about two-thirds of its circum-

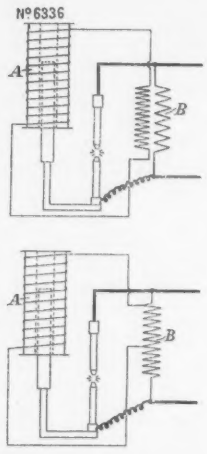


ference on the inlet side thereof, an annular wall F is provided, thus providing two passages X, Y for the incoming liquid, one extending in each direction around the annular wall, and communicating with the main part of the pump chamber, wherein the pump wheels are located. One end of the driving wheel shaft S is mounted in the same way as the pump wheel shafts K, L, whilst the other end extends through the pump casing, and carries a driving pulley P, a stuffing-box joint being employed at this point. In practice, the incoming liquid passes through the two diverging passages around the annular wall, without coming into contact with the driving wheel, to the main part of the chamber and pumping wheels, and, as the pumping wheels are pumping away from the driving wheel, it will be obvious that there is no pressure of liquid in this wheel and no tendency to leak at the stuffing-box joint.—*May 24th*, 1911.

LIGHTING AND HEATING.

6336. March 14th, 1911.—IMPROVEMENTS IN ALTERNATING-CURRENT ARC LAMPS, *Körting and Mathiesen, Aktiengesellschaft, Leutzsch, Germany.*

It is common knowledge that an arc maintained by an alternating current occasionally acts as a converter to direct current, so that direct current may be taken from the arc. In alternating-current lamps in which the feed mechanism depends wholly or in part on the movement of an iron core, or an iron armature under the action of a shunt-wound solenoid or electro-magnet, this class of direct current, which occasionally arises, leads to difficulties in the feed control of the lamp, as the direct current affects the magnetic system. To obviate these difficulties, it has been found that the shunt-wound coil or magnet should not be connected directly across the arc pressure or lamp pressure, but should be connected to the secondary circuit of a small transformer of which the primary circuit is connected across the lamp or arc pressure. The transformer can either be wound with separated primary and secondary circuits, in which case it eliminates practically any direct-current effect in the secondary circuit, or it can be a transformer of the one-circuit type usually known as an auto-transformer, in which case the effect of the direct current on the magnetic circuit is reduced. The upper engraving shows the first and the lower engraving the second circuit referred to. A is the shunt coil of the feed mechanism; B is the transformer. A

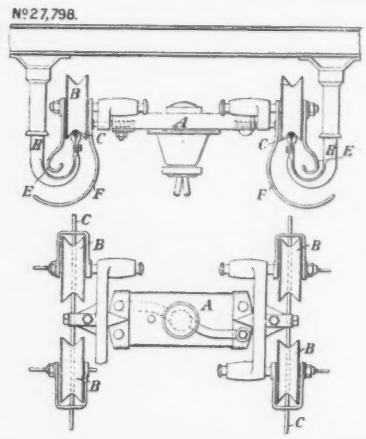


further advantage of enclosing a small transformer in the arc lamp is that the secondary pressure can be selected as required, so that the winding of the magnet coil need not be calculated in regard to the lamp pressure, but, if desired, can be identical for various types of alternating-current arc lamps.—*May 24th*, 1911.

TRAMWAYS AND RAILWAYS.

27,798. November 29th, 1910.—IMPROVEMENTS IN OR RELATING TO COLLECTORS FOR ELECTRIC TRACTION ON THE OVERHEAD CONDUCTOR SYSTEM, Herbert Sefton-Jones, of the firm of W. P. Thompson and Co., 285, High Holborn, London, W.C.

The present invention relates to improvements in or relating to a so-called rail-less trackway. The contact trolley A travels with the wheels B B upon the two conductors C C, and transmits the current to the vehicle through a double cable. As it may occur during the journey that the vehicle must move considerably to one



side in order to pass another vehicle, the contact trolley might possibly be pulled down together with its contact rollers from the conductors by the sideways tension of the cable. In order to obviate this and to prevent the complete removal of the trolley from the conductors, catch hooks are provided projecting underneath in a bent form at both sides of each contact roller, of which the outer hooks E have a short bend and the inner hooks F a larger bend. As the conductors must be supported by carriers, these carriers are bent in a U shape, so that within the curve of the carriers H the smaller hooks, and on the outside the larger hooks on the inside can pass by.—*May 24th*, 1911.

MINES AND METALS.

12,343. May 19th, 1910.—IMPROVEMENTS IN THE CARBURISATION OF IRON AND STEEL. *Samuel Schrack Eveland, of No. 812, Montgomery-avenue, Bryn Mawr, in Montgomery, Pennsylvania, U.S.A.*

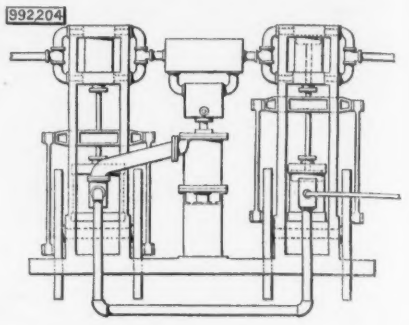
This invention relates to those processes ordinarily referred to as case-hardening or cementation processes, whereby carbon is caused to penetrate the surface of and pass into iron or steel, thereby increasing the carbon content of the metal, the extent of such penetration depending upon the conditions under which the process is conducted and the nature of the agent employed. It is applicable not only to the ordinary case-hardening processes, as heretofore practised, but also to those cementation processes by which large masses or plates of metal are carburised. The carburising agent employed is the fibrous remnant left after the extraction of sugar from beet. This refuse is readily obtainable in large quantities, and consists of a fibrous mass which may be dried. In the process this material is used either with or without comminution, and either simply dried or more or less charred. It is brought into proximity to the surface of the metal which is to be carburised, and both are subjected to the required degree of heat within a substantially closed receptacle. As the result, it has been found that a carburisation which is more uniform and of greater depth is obtained in less time than by the use of other materials which have heretofore been employed for this purpose.—*May 24th*, 1911.

SELECTED AMERICAN PATENTS.

(From the United States Patent-office Official Gazette.)

992,204. AIR BLOWING OR COMPRESSING APPARATUS, *J. E. Johnson, jun., Ashland, Wis.—Filed November 19th*, 1910.

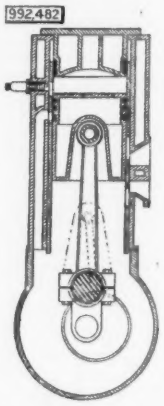
This patent is for the combination of a low-pressure steam turbine driving a centrifugal blower, with a reciprocating engine and compressor, for example, of the type known as a blast furnace blowing engine; the combination and arrangement being such that the low pressure steam discharged by the engine drives the turbine, and the air from the turbine-driven blower is supplied to the



air cylinder of the compressor in a partially compressed condition, thus increasing the capacity of the latter and decreasing its work. There are five claims.

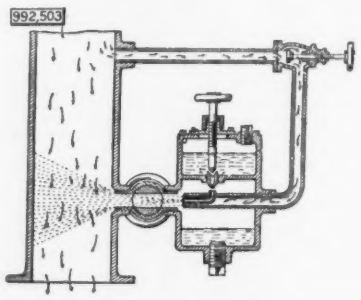
992,482. EXPLOSION ENGINE, *H. E. Coffin, Detroit, Mich., assignor to Chalmers-Detroit Motor Company, Detroit, Mich., a Corporation of Michigan.—Filed March 1st*, 1909.

This patent is for the combination with a piston, of a cylinder forming the explosion chamber, this cylinder being provided with a port and having a recess in one side above the highest point of



travel of the piston, an electric igniter is placed within this recess. A cylindrical sleeve between the piston and cylinder forms a valve for controlling the port, being provided with an extension serving as a shield for covering the recess subsequent to the explosion. There is only one claim.

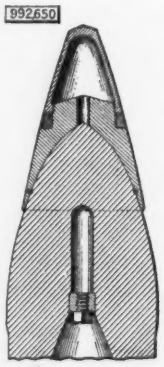
992,503. LUBRICATOR, *B. F. Howard, Indianapolis, Ind., assignor of one-half to J. W. Staub, Indianapolis, Ind.—Filed October 25th*, 1910.



This patent is for a "steam greaser" of the induction type. Its action will be understood from the drawing. There are eight claims.

992,650. PROJECTILE, *E. Gathmann, New York, N.Y.—Filed February 23rd*, 1910.

This projectile has a body portion having a hardened tapered head and point, a tapered soft metal cap mounted on it. A hollow



wind cap is mounted upon the forward portion of the soft metal cap, and a reinforce is placed between the thin walls of the wind cap and the forward portion of the soft metal cap. There are nine claims.

THE COST OF EXCAVATION ON LARGE ENGINEERING WORKS.

No. I.

ON engineering works of magnitude the excavation work is, as a rule, responsible for a very large proportion of the total cost.

The writer knows of no English book which deals thoroughly with the subject from the point of view of cost. The well-known builders' and contractors' price books give no information which would enable an engineer or contractor to estimate accurately the cost of excavating a large cutting. Any amount of information is available on design, and the purely engineering side, but very little on the business side of the problem gets into the Press. This is probably due to the system of carrying out almost all our important works by contract, so that engineers have not much opportunity of acquiring first-hand knowledge. The young engineer serves his articles with some experienced member of his profession, and so obtains a knowledge of contract prices for various kinds of work, but as tenders for the same work vary very considerably, he has no means of knowing whether the contract price is a fair one, at which the contractor could make a fair profit and no more, except by comparison.

When work is carried out by administration, and costs are made public, they are not given in such a way that they can be used by anyone other than the compiler as a basis upon which to work for future estimates. All the particular conditions obtaining on that particular piece of work may not occur again in a lifetime, but some of them will be repeated on almost every piece of work carried out. Those engineers who have carried out a large amount of work and who have a great many tenders on file are in a position to give a fairly accurate estimate of what the work is worth. The younger engineer is not so fortunate, and has to make the best guess he can. The writer has for some years been connected with a contracting company carrying out works of considerable importance. He has collected a good deal of information on the cost to the contractor, and gives some of the details in this article.

When recording the cost of any piece of work it should be obtained in such a way that it can be used with safety at a later date to estimate on work of a similar nature under different conditions.

To do this involves a careful analysis of the unit cost into its component parts. Take the case of concrete as an example. The cost of this is made up of the costs of breaking the stone, or screening gravel, measuring, mixing, or turning, wheeling, depositing; making, erecting, and taking down shutters. When a cost is split up in this way it is easy to compare one piece of work with another, and so use it in estimating upon future concrete work; thus on one job the concrete materials may be obtained from the excavation, on the other they may have to be purchased; there is then the cost of materials as against the cost of breaking. One man wants the materials turning four times, another six, the turning cost thus being increased 50 per cent.; one man wants it well ramming, another doesn't; one case may require expensive shuttering, the other be foundation work not requiring any shuttering at all. Sufficient will have been said to make it clear that a unit cost per cubic yard is not of much value to anyone but the compiler, unless all the conditions are known.

When costs are being kept every expense, however small, should be booked, so that totals may be checked with the wage sheets and bills. The total shown on the wage sheets is taken as being the labour cost, and the sum total of the various units must agree with this. If they are dealt with without comparison with the wage sheets one cannot be sure that everything is included. The accounts are dealt with in a similar way, and when the sum total of the amounts booked to all the various items agree with the amount of bills paid it is certain then that everything is accounted for.

The writer does not believe in taking the cost for a few days or weeks at a time; this method does not make sufficient allowances for the delays and breakdowns inseparable from work carried out on a large scale, and the resulting cost is sure to be too low. The most accurate way is to check the wages each week with the details of the cost, treat the bills in the same way at the month end; then, when the work is completed, there can be no doubt that everything has been included, and the unit cost is bound to be correct. The only mistakes that can occur are in the process of analysis; it is possible for some of the details to be slightly over-charged, and others slightly under.

The preliminary expenses should be carefully considered. These, with part of the retention, show the necessary amount of capital required to work the job. Before these expenses can be ascertained the quantities must be worked out, and the time in which the work has to be done fixed, as the preliminary expenses largely depend on the progress required, this governing the expenditure on plant.

When a large number of men are brought suddenly into a country district, it is not often that the surrounding villages can accommodate them; when they cannot, huts have to be provided. These increase the preliminary expenses, but the rents should pay interest and depreciation, and cost of erecting and taking down. It is always advisable to have one or two huts on the work, so that a few men can be had at once to deal with any emergency. Water supply is often a source of considerable expense. As a rule, water found in the district should be analysed before it is decided to use it for steam. It is far better to pay 1s. a thousand for good water, and go to considerable expense in laying it on, than ruin good boilers.

Other expensive items covered by the term preliminary expenses are—Providing and erecting sheds and workshops. Railway carriage on plant is generally a large item; of course, if new plant is purchased this is not charged directly. The carting to site and erection of plant, or the construction of a siding from the nearest station, instead of the carting, where it can possibly be done. Where much carting is done there is liability for a claim for excessive traffic. Should there be only one railway near and a siding is decided upon, the railway company may charge anything up to £400 for putting a crossing into the main line; of course, if there is any competition it will get put in for nothing. All these points should be borne in mind when going over the site. It is advisable to draw up a list of all the main items of plant required; 10 per cent. should be added to the total to cover the tools and the light plant. There is also the value of the work accomplished up to the date of the first certificate to allow for, and the retention. Only a rough estimate can be made, and the more experienced the estimator the better the result. The object of this, as mentioned before, is only to find out approximately how much capital will be required to carry on the work, and liberal allowances should be made.

One of the first difficulties met with in collecting cost data is what to do with the numberless items, some small, some large, which cannot be charged to any particular piece of work. The writer's way of dealing with them has been to collect all such items on to one sheet, headed "General Work and Expenses," and charge the total as a percentage on to the wages of the men doing the construction work, and maintaining the main units of the plant in running order. This sheet is divided into a large number of sub-headings, one for almost every item, so that the sheet can be analysed when required.

Repairs to plant are, where possible, charged to the machine in question, so that the cost of running that particular machine is available for future reference. But there are expenses in connection with the repair of the smaller items of plant, which may be termed tools and light plant, it would be impracticable to try and follow. These are brought on to the general work and expenses sheet, and are covered by the percentage added to the wages. They are dealt with in this way to facilitate making out prices for future work. The main sub-headings included on the sheet are the following:—

Labour items:
- Unloading plant, workshops, &c.; getting to site and erecting.
- Laying on and maintaining water supply.
- Staff.
- Repairs to tools and light plant.
- Watching and lighting.
- Temporary fencing.
- Stack plant at completion.
- Sundry items of a similar nature.

The labour cost of these items will add from 20 per cent. to 30 per cent. on to the wages paid to the men doing the construction work and maintaining the main units of the plant in good running order.

Of the accounts charged under this heading the more important are:—
- Office expenses.
- Railway carriage on plant.
- Compensation for damage.
- Sundry accounts of a similar nature.

These will add a further 7½ per cent. to 10 per cent., making the total percentage to be added of from 25 per cent. to 40 per cent. In this way of estimating nothing is added to the accounts, a cost being made up of labour + general expenses + plant hire and accounts.

No exceptional temporary works are allowed for under this heading, such as large temporary bridges or stagings. These are estimated separately according to the amount of work there is in them, and a price per cubic yard is added to cover them.

The excavation proper is divided into three headings, filling, hauling, and tipping, the filling being sub-divided into hand and steam excavator work, the latter only being considered here. Points which affect the cost of steam excavator work are the kind of earth to be filled, quantity, depth and width of cutting, and whether working up or down hill—when working down hill there is sure to be trouble with surface water. If the slope has to be trimmed this should be measured separately in square yards, both in cutting and bank, and a separate price charged for it. If the contractor has to take this out for himself, he takes an average cutting and an average bank, and adds to the cost of filling, the cost of trimming the cutting slopes, and to the tipping, the cost of trimming the bank slopes. There are some cases where trimming is not required, and in such cases, if included in the excavation price, it would get paid for even if not done. The thing, of course, that affects the price of filling more than anything else is the character of the material to be moved. It is well worth while spending money putting down a number of trial holes, to make sure of what the material really consists. A contractor would sooner guess at anything than this. Bore-holes are not very satisfactory; those within the writer's experience, at any rate, have not been so. Even trial holes sometimes give a wrong impression in faulty ground, but they are the best thing a contractor can hope to get. They are also necessary to the engineer before he can safely fix the angle of the slope. When he has fixed it he should be responsible for it, and not put a clause in the specification that if he finds it necessary to do so, he may at any time tell the contractor to flatten the slope, and should he decide to do so, the work must be done at schedule rate. It has to be taken off by hand and re-trimmed, and should be paid for accordingly. The engineer can protect himself by inserting an item in the quantities for this work, and if he puts a quantity down so that it adds out in the tender, he need not fear having to pay an exorbitant price. The writer thinks it is a mistake to try and make the contractor responsible for things over which he has no control, such as a slip; of course, it is quite right for the engineer to protect himself from the results of improper procedure on the part of the contractor, but a slip caused by making a slope too steep, or by a wet place not ordered to be properly drained is no fault of the contractor's, and he should not be held responsible. Trying to make him responsible only leads to gambling; one contractor will chance it, another will not, with a consequent wide variation in the tenders.

Dealing with the filling first, the quantity and the time fix the daily output. When fixing the time, it should be remembered that it takes considerable time to get started, and time after the completion of the excavation to do the works which cannot be done until the excavation is finished, and allowances must be made to cover this and also delays due to bad weather and accidents. Here it will be well to mention that a steam excavator works a great many less shifts per year than anyone who has not had charge of one would suppose. Two cases taken from the writer's records will serve to illustrate this:—

	Case 1. Hours.	Case 2. Hours.
Possible hours (full time)	2371½	1825½
Delays for—Wet	114	124
Blasting	174½	73½
Repairs	27	43½
Horses	¾	¾
Wagons	39½	59
Steam	—	3½
Water	—	3
Standing	182	51
	537½	352
Deduct delays for standing	182	51
Net total of delays	355½	301
Per cent. of net delays to full time	15	16

Not counting the time standing, at least 15 per cent. can be allowed to cover delays when the machine is at work, or only five ten-hour shifts as the most a steam excavator can be estimated to work in a full week of 56½ hours. A full year, less holidays and Sundays, may be assumed at 285 ten-hour shifts, under the best possible conditions, should there be no delays for anything. The ordinary unavoidable delays will reduce this time by 15 per cent., or forty-five shifts, which might be counted upon on the assumption that the machine was working at one face the whole year. This rarely occurs in practice. It might be possible to get about this number of shifts bearing rock or ore in mines, but in ordinary engineering work the machine has to be moved from cutting to cutting, and has to stand often enough for days together. The writer would not assume that more than 200 shifts would be worked by each machine in a year, whilst the work was in progress, and when making allowances for depreciation this figure should be remembered.

There are parts of the cuttings which have to be taken out by hand; for instance, a place must be formed for the machine to start in, and when it is moved to a second cut, another place. There is also the earth left on the slope which the excavator cannot reach; about 6ft. high is as far as the bucket will follow the slope line. The earth above this point has to be either worked down into the bottom so that the excavator will fill it as it goes along, or left on the slope until the machine has worked some distance ahead and then filled direct into wagons by hand. Some engineers object to the latter method, as it may cause a slip. The quantity so filled by hand may be taken at from 5 per cent. to 10 per cent. of the cutting.

A modern excavator equipped with 1½ cubic yard bucket, working in easily filled ground, can average about 600 cubic yards measured in the solid per ten-hour day when working under the most favourable conditions. In fairly stiff shale and clay 450 to 500 cubic yards. In strong ground with occasional beds of rock 350 to 450 cubic yards. Nothing but experience will enable anyone to predict with confidence what the average daily output will be. Much larger outputs than 600 cubic yards can be obtained often for weeks together, but if at the end of the work the quantity of excavation paid for is divided by the number of shifts worked, there are not many cases where 600 cubic yards will be exceeded.

The excavating time and the estimated average daily output determine the number of machines required. Buying second-hand excavators on large work is not advisable, unless they have done practically no work. When they are used there are always delays due to breakages, which do not occur with new machines. Steam excavators are subject to very severe shocks when at work, and unless they are in first-rate order a lot of time is lost in repairing, and worse, both foreman and driver lose interest. The expense of working a steam excavator in a full round face may be taken as below.

	£ s. d.
The wages of men specified below will amount per shift worked to about	4 13 3
Should the slope have to be got down as the machine advances, it will take two to three men on the slope, allow, say	0 10 6
The labour cost of repairing excavator and including for washing out, burning out and examining winding chain, tightening up bolts, &c., on a new machine should not exceed 3s. to 4s. per shift	0 4 0
If the machine was second-hand in fairly good condition, this item will be 10s. to 15s. per shift.	
Total labour cost	5 7 9
Add to cover general expenses, 33⅓ per cent.	1 15 11
Coal, say, 30 cwt. at 12s. ton = 18s., and 2s. for water	1 0 0
Accounts for repairs to excavator, if new, about 0 3 0 If second-hand, about 12s.	
Accounts for water pipes and fittings, sundry hardware, oil, waste and packings	0 3 0
Fodder for two horses, including shoeing, harness, and vet.	0 8 0
Interest and depreciation, assuming 200 shifts per year	1 10 0
Cost per shift	£10 7 8

Foremen and horse drivers are generally paid by the day, wet or fine. This is worth at least 6d. per day extra, and in the figures allowances have been made to cover it. Three men are required on the excavator itself—driver, fireman, and wheelsman. Each of these men is paid by the hour and each has allowances made to him. The driver has to oil round before starting time and to tighten

up loose bolts, &c., at meal times. The wheelsman has to fat the winding chain. The fireman has to have steam up for starting time and to draw fire at night. The rest of the men are paid the time they work. It takes five men to clean up and get the machine ahead promptly; one man to look after the coal and water supply; two men putting in jumps to keep the empty wagon road close behind the machine, so that no time is lost between wagons; two horses and drivers; one or two wagon stoppers; three boys to fat wagons, turn points, and take trace chains from full to empty wagons; one foreman.

If pumping will be required an amount should be added to cover this. Sometimes a third horse and driver is required when filling considerable quantities, or when the work is hard. The above total, divided by the daily output, gives the cost per cubic yard for filling on to wagons with steam excavator. There is then to allow for the part that is done by hand. This is small, and generally not done economically, and may be assumed to cost 1s. per cubic yard more than filling with steam excavator. The final cost, assuming an average output of 600 cubic yards and 5 per cent. by hand, is :—

		d.
95 cub. yards at	4.15 =	394.25
5 ,, ,,	16.15 =	80.75
100 cub. yards cost	...	475.00
1 cub. yard costs	...	4.75

It is not much use recording hauling as a cost per cubic yard. On one job it may be necessary to move the excavation three or four times as far as on a second, and, other things being equal, the cost would be three or four times as great. Cost kept on a cubic yard mile basis is not entirely satisfactory, unless accompanied by particulars; the gradients and the total quantity largely affecting the result. The writer prefers to work out the cost in different ways, recording the result in cubic yard miles. Under the head of hauling is charged :—

(1) The whole of the expenses connected with the temporary plate laying, except such work as is done by the steam excavator gang, and charged under filling, whose work consists of putting in jumps and metalling ahead as the excavator moves forward, and the work of the tippers on the end tank, metalling ahead as the bank proceeds. The work of shortening up both the excavator and on the bank—usually done at week ends—is charged to temporary roads or "track."

(2) The expenses connected with the locomotive power.

(3) The whole of the expenses connected with the wagons. Taking the temporary roads or track first. These are generally laid with 56 lb. to 60 lb. rails weighing 88 to 94 tons per mile, with 8.0 by 8 by 4 Scotch fir, partly square or Baltic sleepers. Very few half-round sleepers are used; the only place where they are any good is in lifting a side wagon bank. The great objection to them is that after a dog has once been driven into them they are practically useless.

As regards the weight of rail to be adopted the heavy rail has almost all the advantage; it will not cripple so easily, and so a wider spacing of the sleepers is permissible, and as rails can be turned into cash more easily than any other item in the plant a few pounds extra spent in buying heavier rails will prove economical because of the saving in sleepers, for which very little can be realised after they have been in use a couple of years. The advantages of the lighter rail are lower first cost, and a less cost in railway carriage to move it from one job to another; also there are occasions when a close spacing of sleepers has to be adopted on wet ground to support the weight of the train, then the light rail is better.

THE NORTH-SOUTH UNDERGROUND RAILWAY IN PARIS.

ON the 5th November last the principal line of the "North-South Underground Electric Railway Company" of Paris was opened for traffic. It has already come to be called simply the Nord-Sud, and was fully described in a recent issue of our esteemed contemporary, *Le Génie Civil*, from which account the following article, with its illustrations, has been prepared. In the first instance we may draw attention to the plan map—Fig. 1—showing all the Paris underground lines whether at work, under construction, or authorised, as they were on December 1st last. The net work comprises the following :—(1) The eight original lines which were sanctioned by the law of March 30th, 1898. With the exception of line No. 8 and the ends of line No. 7, these were all actually in operation. They are marked full black in the plan, and they are as follows :—

Line 1. From the Porte de Vincennes to the Porte Maillot.
„ 2. Circular by the Old Outer Boulevards.
„ 3. From Courcelles to Ménilmontant.
„ 4. From the Porte de Clignancourt to the Porte D'Orléans.
„ 5. From the Gare du Nord to the Austerlitz Bridge and the Place d'Italie.
„ 6. From the Cours de Vincennes to the Place d'Italie.
„ 7. From the Place de Danube to the Palais-Royal.
„ 8. From Auteuil to the Opera House *vid* Trenelle.

Nine further lines are shown on the map. These were sanctioned by the Municipal Council in December, 1907, and definitely conceded by the law of 30th March, 1910. They are marked thus ▬▬▬▬ on the plan, and are as follows :—

(A) Prolongation of line 7 from the Palais-Royal to the Hôtel-de-Ville, to the Boulevard Morland, and to the Bastille.
(B) Prolongation of line No. 3 to the Porte des Lilas, with a connection with line No. 7 near the Porte de Pré-Saint-Gervais.
(C) Line from the Porte d'Orléans to the Porte de Gentilly.
(D) Prolongation, from the Trocadéro to the Opera House, and eventually to the Carrefour Druot, of the line from the Porte de Saint Cloud to the Trocadéro *vid* the Place de l'Alma.
(E) Branch line from the Bastille to the Porte de Picus.
(F) Inner circle railway Les Invalides to Les Invalides.
(G) Line from the Porte de Choisy and the Porte d'Italie, with a connection with line 4 at the Carrefour de l'Odéon.
(H) Line from the Porte de Montreuil to the Place de la République.
(J) Line from the Place de la République to the Porte des Lilas.

Finally, by reason of the order of the Municipal Council of 23rd December, 1907, already alluded to, backed up by a Convention made in June, 1909, between the Prefect of the Seine and the Metropolitan Railway Company, the city of Paris conceded to this company the right of eventually constructing the lines shown thus ▬•▬•▬•▬ on the plan, which are as follows :—

K. Branch from line 8 to the Porte de Sèvres.
L. Branch from Saint-Augustin to the Porte des Ternes, with eventual prolongation to the Porte Maillot.
M. The cental portion of the Porte de Choisy and the Porte d'Italie to the Place de la République.
N. Branch from the Boulevard de la Villette to the Porte de Pantin.
O. Junction line between lines 8 and 4 from the Mirabeau bridge to the church of Montrouge.

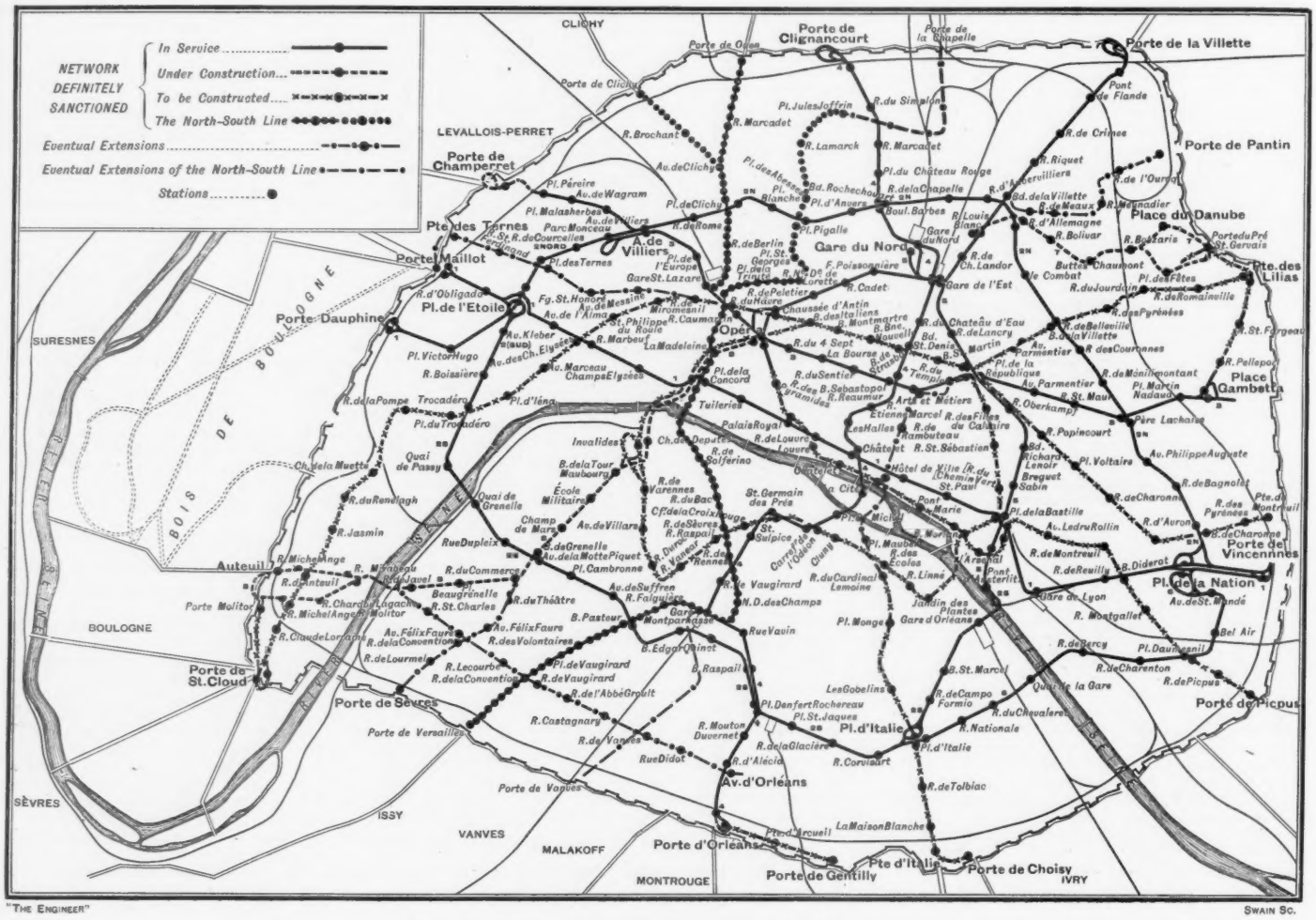


Fig. 1—THE UNDERGROUND RAILWAYS OF PARIS

An examination of the map will reveal the fact that of the original eight lines only two—namely, Nos. 4 and 5—serve the traffic taking place in a general direction from north to south. All the others tend more or less east and west. It was felt imperative, therefore, to construct a line passing through the centre of the city, and joining its north with its south side. This want was very early foreseen, and as long ago as a year before the metropolitan line No. 1 was put in operation, a concession was sought for an underground electric railway to start from the Montparnasse Railway Station and to run to Montmartre, passing the St. Lazare Station on the way. In a slightly extended form this concession was granted in December, 1901, the extensions being on the one hand to the Porte de Versailles, and, on the other hand, to the Porte de St. Ouen. It will be unnecessary to go in detail into the various delays which this scheme underwent, and it will be enough to say that as finally decided upon the north-south line as actually undertaken resolved itself into two distinct lines :—(*a*) A line running from the Porte de Versailles to the Place Jules-Joffrin, having a total length of 10,800 m.—nearly 6¾ miles; and (*b*) a line running from the St. Lazare Station to the Porte de St. Ouen having a length of 2650 m.—rather over 1⅝ miles. This line has a branch to the Porte de Clichy.

In addition to these it is eventually intended to make a branch from the Montparnasse Station to the Porte de Vanves and from the Place Jules-Joffrin to the Porte de la Chapelle. Unlike the Metropolitan lines proper, the substructure of which was carried out entirely at the ex-

pense of the city, the north-south lines have had to be constructed and run in their entirety at the risk and cost of the company which holds the concessions for them. As a set off to this, however, the company has received certain subventions and privileges into which, however, it will not be necessary for us to enter.

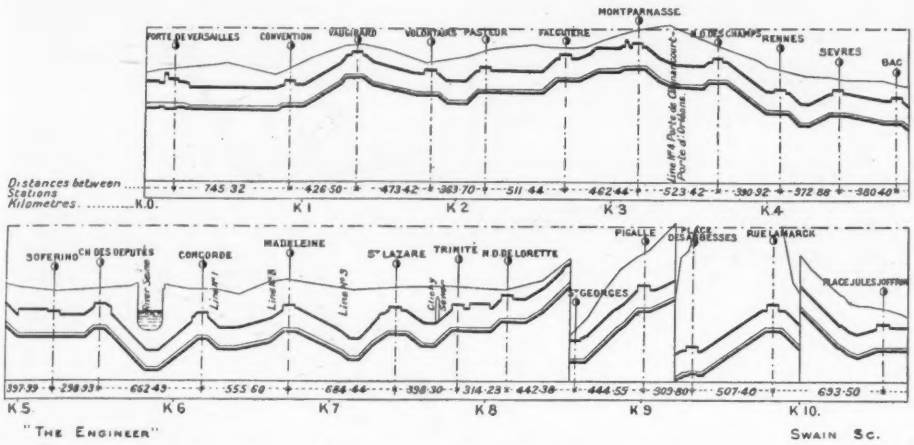


Fig. 2—PROFILE OF THE LINE FROM PORTE DE VERSAILLES TO PLACE JULES-JOFFRIN

The Port de Versailles—Jules-Joffrin line, as may be seen in Fig. 3, starts from the extremity of the Rue de Vaugirard, which it follows for a distance of nearly three kilometres, and then proceeds by the Place de Rennes and the Boulevard Montparnasse to the church of Notre-

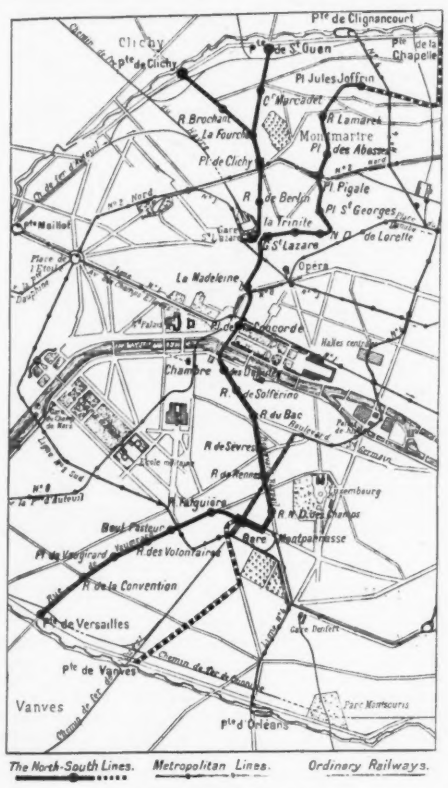


Fig. 3—THE NORTH-SOUTH LINE

Dame-des-Champs, thence by the Boulevard Raspail to the Boulevard St. Germain, passes under the Seine in two separate tubes, and reaches the North Bank near the Place de la Concorde. It runs from thence, by the Rue Duphot and the Place de la Madeleine, to the St. Lazare station, la Chapelle. It is to be remarked that the ends of the lines are not provided with loops to enable trains on arriving at the terminations of their journeys to pass from one line to another. This operation is carried out by shunting. There are, in all, 23 stations between the Porte de Versailles and the Place Jules-Joffrin, the average distance between each being a little more than 500 metres —nearly 550 yards—the greatest distance being 745 metres, and the least 299 metres. Six of these stations are in communication with lines of the Metropolitan Company. One of the conditions imposed upon the undertakers of the line was that where the station level exceeded 12 metres—nearly 40ft.—below the surface of the ground, lifts were to be provided. As a matter of fact in only two cases have lifts had to be provided. One of these is the Place des Abesses, where the depth is 22.6 metres, and the other the Rue Lamarck, where it is 16 metres. The method of obtaining access to one of the stations—that in the Rue Solférino—is shown in Fig. 7.

In the original project of the undertaking it was intended that the line should be made at a considerable

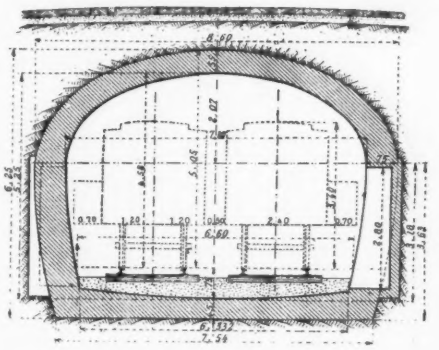


Fig. 6—TYPICAL SECTION OF TUNNEL

depth in order to avoid the sewers, water and gas pipes, &c., and so as not to interfere with the foundations of the houses, especially those in narrow streets. This idea was abandoned, partly because of the difficulty which would be experienced by passengers in getting to and from the stations, and partly because the construction of the tunnel would have been very difficult on account of underground water, and it was decided eventually to make the line as near as possible to the surface of the ground. The gradients of the line—see Fig. 2—from its starting point at the Porte de Versailles are comparatively slight up to the Boulevard Montparnasse, where it passes for the first time under the Metropolitan line No. 4. It does so again where it crosses the Rue de Rennes. It comes again near the surface under the Boulevard Raspail, and continues thus to the Rue de l'Université, where it has to go under the lower left bank collecting sewer. On leaving the Chambre des Députés stations the line descends in order to pass under the Seine. This it does in two separate tubes. The river passed, the line mounts to the Place de la Concorde, but remains at a sufficient depth to pass under the Metropolitan lines No. 1 in the Rue de Rivoli, No. 8 under the Boulevard de la Madeleine, and No. 3 under the Boulevard Haussmann. At this point special arrangements were necessary in order to facilitate the eventual construction of a projected line to be known as the Opéra-Ternes. From the Gare St. Lazare to the Place des Abesses, and then from the Rue Lamarck to the Place Jules-Joffrin, the line keeps as near the surface as possible, only descending when it is necessary to pass under a railway or a sewer, as for example in the Place de la Trinité where the Clichy sewer is met with, and at the Place Pigalle, where Metropolitan line No. 2 is passed. On the other hand, in the portion under the Butte

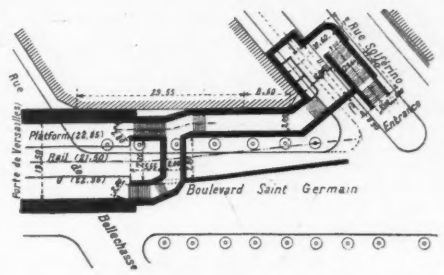


Fig. 7—TYPICAL APPROACH TO STATION

Montmartre the rail level is at a considerable depth—from 23 m. to 56 m., say 75ft. to 184ft. Here the tunnel is pierced in solid rock, so that its passage under houses might not produce any ill effects.

The branch line to the Porte de Saint Ouen and to the Porte de Clichy starts from near the Gare St. Lazare opposite the Hôtel Terminus. Here it is in communication with the main Nord-Sud line by means of an intercommunication passage. It first of all follows the Rue d'Amsterdam, and then the Avenue de Clichy, to a point called "La Fourche," where it divides into two branches, one going to St. Ouen and the other to Clichy. The stations between the Gare St. Lazare and St. Ouen are six in number—including the termini—namely, Gare St. Lazare, Rue de Berlin, Place Clichy, La Fourche, Rue Marcadet, and Porte de Sainte Ouen. The total length of the line is 2650 metres, and the average distance between stations is 500 metres. The branch from La Fourche to the Porte de Clichy is rather shorter than

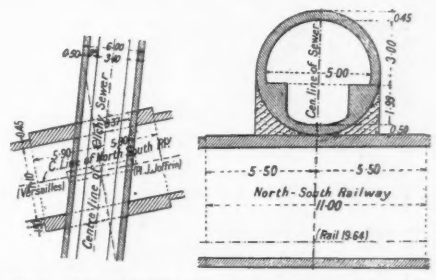


Fig. 8—LINE PASSING UNDER THE CLICHY SEWER

that to St. Ouen. As far as its only intermediary station —Rue Brochant—it will be of the ordinary construction, *i.e.*, single tunnel with two sets of rails, as shown in Fig. 6, which gives a typical cross-section of the tunnel. On leaving this station, however, the line is divided into two tunnels each with a single set of rails, each tunnel coming under a footpath of the avenue. This construction has been necessary in order to avoid interfering with the Clichy sewer. These two lines join one another near the Porte de Clichy in two stations—arrival and departure, being connected together by means of a ring loop.

The general construction of the Nord-Sud line is very little different from that employed throughout the Metropolitan lines. The greatest width of the tunnel is the same — 7.10 m. — and also that of the stations—13.5 m., the platforms being 4.10 m. wide. The Gare St. Lazare station is the only exception. Here the platforms are made 5 m. wide, and the total width of the station becomes 15 3 m.—just over 50ft. The arches and lateral walls of the rooms, galleries, and passages have either been constructed of masonry composed of millstone grit set in cement mortar, or in concrete or armoured concrete. The walls have been covered with enamelled

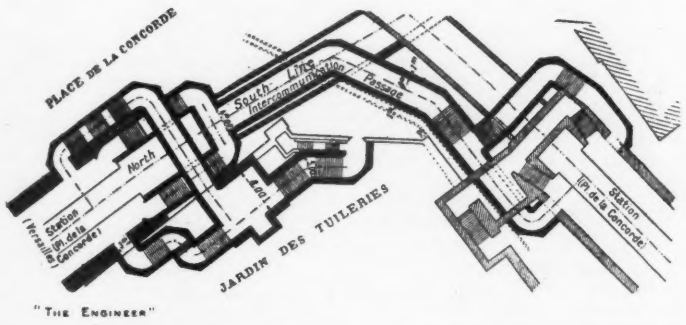


Fig. 4—CONNECTIONS BETWEEN THE TWO STATIONS—PLACE DE LA CONCORDE

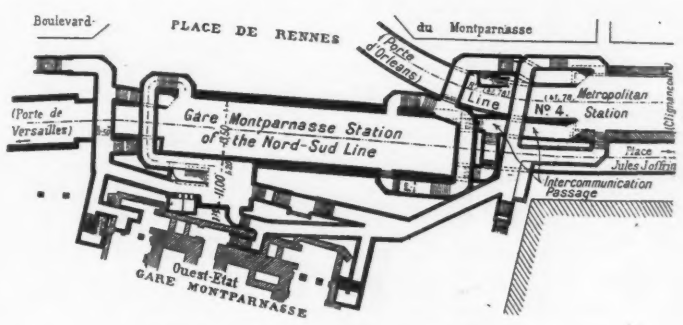


Fig. 5—THE GARE MONTPARNASSE STATION

and at present terminates near the church of Notre Dame de Lorette, though eventually it will proceed by the Place St. Georges, the Place Pigalle, the Place des Abesses, the Rue Lamarck, and the Place Jules-Joffrin to the Porte de

tiles. The soffits of the arches over the platforms and passages are plastered. The names of the stations are set out in large white letters on a dark blue ground, and are very easily seen. The spaces devoted to advertisements

are divided off into squares by brown earthenware frames in ordinary stations and by blue frames in stations where a junction is formed with another line.

The Nord-Sud Company, by reason of the special conditions under which the concession was granted to it, as well as because the line was made after the Metropolitan, has had to overcome difficulties which the latter line did not one on each side where its side walls came. These were built by means of galeries 2.65 m. high driven under the sewer. The arch of the railway was then gradually built in, and then the side walls, the flooring of armoured concrete being put in last. The work, which was a fine piece of engineering, is apparently thoroughly satisfactory.

The stations where there is an exchange of passengers crossing the busy thoroughfare. This hall is 30 m.—98ft. 5in.—in diameter. The roof is of metal and is carried on eight steel columns which are coated with glazed tiles.

The narrow width of certain of the streets under which the Nord-Sud runs has necessitated in certain cases a special construction for the stations. In the Rue de

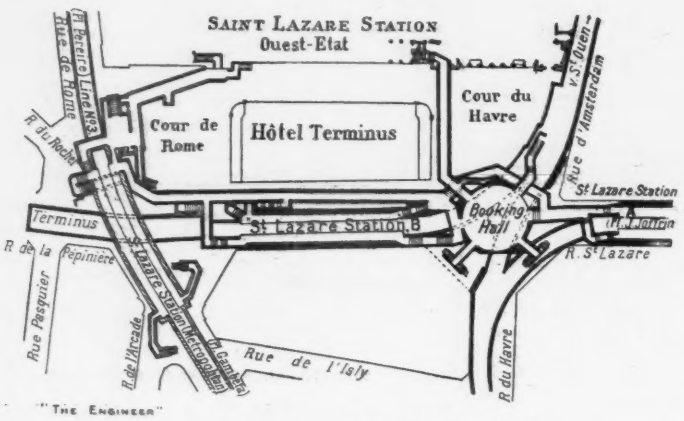


Fig. 9—THE TWO STATIONS AT GARE ST. LAZARE

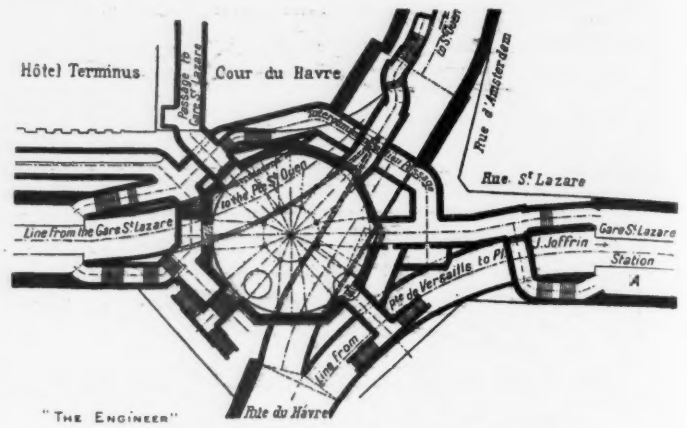


Fig. 10—UNDERGROUND HALL AT LA PLACE DU HAVRE

meet with. Thus, in passing the Metropolitan lines the Nord-Sud always had to go underneath them. This, as may be seen in Fig. 3, occurs a great number of times. The most difficult crossing was that under No. 1 line in the Rue de Rivoli, at the corner of the Place de la Concorde. Here there was only a difference of level between the rails of the two lines of 5.40 m.—17.71ft., and it was necessary to arrange matters so that the road bed of No. 1 line was actually carried on the top of the arch of the Nord-Sud line, which, together with its side walls, was specially strengthened. This work was carried out in sections without interfering with the running of the trains on line No. 1. Among the other difficulties which may be mentioned is the passage under the big Clichy sewer in the Rue Saint Lazare, to the right of Rue Mogador—see Fig. 8. In carrying out this work the ground was first of all consolidated by injections of cement mortar, made by means of compressed air under a pressure of 5 kilos. per square centimetre, in holes having depths up to 5 m. Three temporary walls 1 m. wide were then built under the sewer, one in the centre of the north-end line, and with the Metropolitan lines, "presented," remarks our contemporary, "if not actual difficulties, at any rate considerable complications." The remark would appear to be amply justified by the drawings given in Figs. 4, 5, 9, and 10 of the stations at the Gare Montparnasse, the Place de la Concorde, and the Gare St. Lazare. The first-named is placed opposite the terminus of the State Railways and as near as possible to the Metropolitan Station of the same name. The entrance to the Place de la Concorde Station has been made in the wall of the Tuileries Garden in the corner formed by the Place de la Concorde and the Rue de Rivoli. The Gare St. Lazare Station is a special construction altogether. Not only is it an exchange station with the Metropolitan, but also with the branch Nord-Sud line going to Clichy and St. Ouen, and with the interior of the Ouest-Etat Station. Figs. 9 and 10 show the different communicating passages between these various stations and particularly between the two stations A and B of the Nord-Sud line. They also show the circular underground hall under the Place du Hâvre which, besides giving access to the stations, can also be used by foot passengers desirous of passed through is given in Fig. 14. It will be observed that underneath the river itself the tubes passed through more or less compact limestone, but at the two edges beds of sand and alluvial deposit were encountered, and in these water was met with in considerable quantities. The tunnels were bored from the Chambre des Députés end and from the Place de la Concorde. At the latter

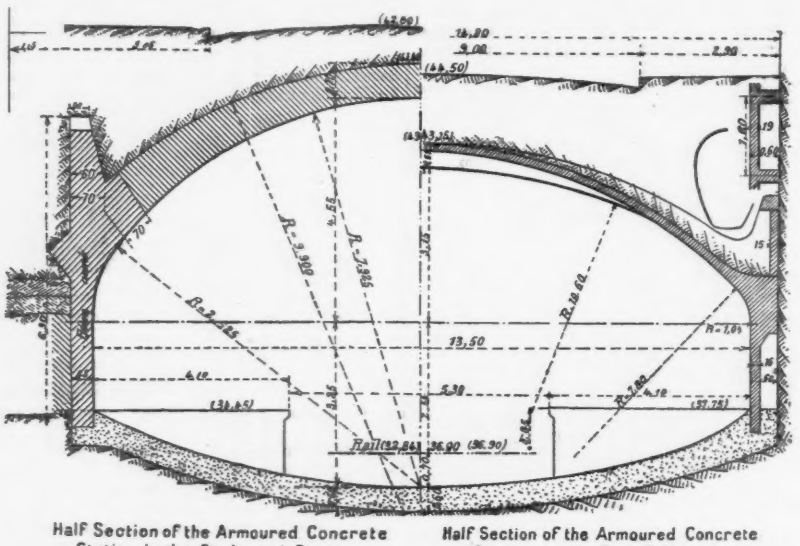

Half Section of the Armoured Concrete Station in the Boulevard Pasteur.
Half Section of the Armoured Concrete Station in the Rue Falguière.
"THE ENGINEER"
SWAIN Sc.

Fig. 11—SECTIONS OF ARMOURED CONCRETE STATIONS

Vaugirard, the width of which is only 14 m., the standard width of station has been maintained by the use of armoured concrete, which has permitted the reduction of the thickness of the side wall from the normal of 2·3 m. to ·60 m., .48 m. and even to .25 m. Three stations have been built in this manner: (1) The Rue Falguière station, (2) the Boulevard Pasteur station, and (3) the Rue des Volontaires station. These stations have been designed by Monsieur Considère. Half sections of the two first are shown in Fig. 11, and details of the Rue des Volontaires station are given in Fig. 12. The price per lineal metre for the three stations in armoured concrete was

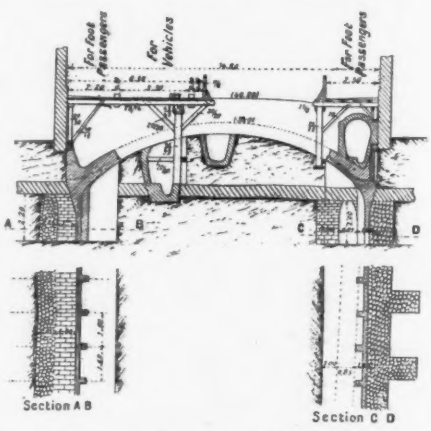


Fig. 12—STATION IN RUE DE VOLONTAIRES

2325f., 4300f. and 3300f. respectively, certain accessory works not included.

In the passage under the Seine each line, as has been mentioned above, is carried in a separate tube. These tubes have been driven in the ordinary manner with a shield, the excavation being lined with cast iron rings. These rings have a width of ·60 m. and are made up of twelve segments. The exterior diameter is 5.240 m., and the interior diameter inside the ribs of the segment of 5 m.—16.4ft. The two tubes start from the Chambre des Députés station and unite again at the Place de la Concorde station. The general line taken is shown in Fig. 13, and a section showing the nature of the ground

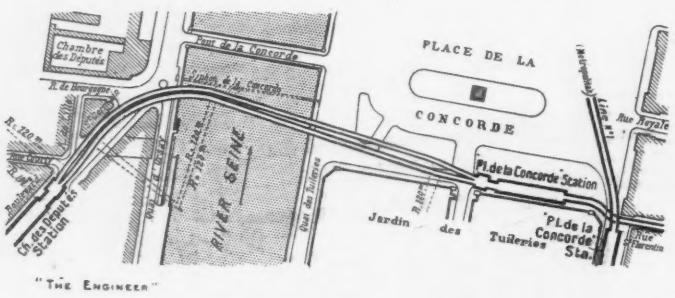


Fig. 13—THE LINE PASSING UNDER THE SEINE

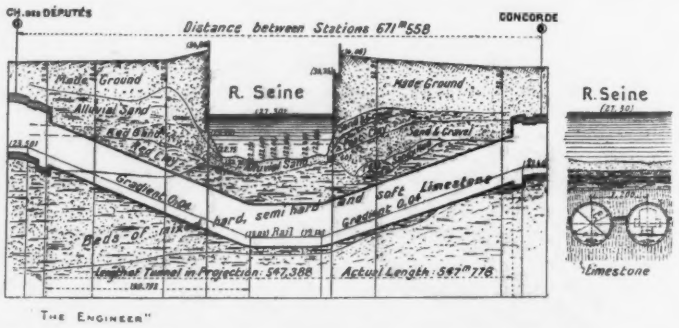


Fig. 14—THE TUNNELS UNDER THE SEINE

place a shaft was sunk and working was carried on in both directions. At a sub-station at the Chambre des Députés station tri-phase current received from generating stations at Asnières and Issy-les-Moulineaux, was employed to actuate hydraulic and pneumatic machinery of a total of some 1200 horse-power for supplying compressed air and water under pressure for working the shield, removing the excavated material and erecting the rings. The shields employed were 4.6 m. long and 5.34 m. in diameter—.1 m. more than the diameter of the finished tubes. They were similar to the shields of which such considerable use has been made in this country, and were provided with twenty-four hydraulic jacks round their circumferences, each jack being capable of exerting a force of 100 tons. The segments of the rings were got into place by means of a mechanically-worked moveable arm mounted on the shield. When the rings were in place they were grouted in the usual manner with fluid cement supplied under a pressure of 1½ atmospheres. Three air locks were employed arranged two side by side at floor level for the entrance and exit of the material, and one placed above these for the workpeople. Apparently a maximum air pressure of just over 21 lb. per square inch was required. A section of the tube showing the lining is given in Fig. 15.

The Nord-Sud line was not allowed to construct electric generating stations of its own, but was compelled to purchase the energy necessary both for the construction, running, and lighting of its line. The horse-power necessary for working its two lines is estimated at 3800 as an average. This it purchases from generating stations at Vitry-sur-Seine and St. Denis, either of which can supply

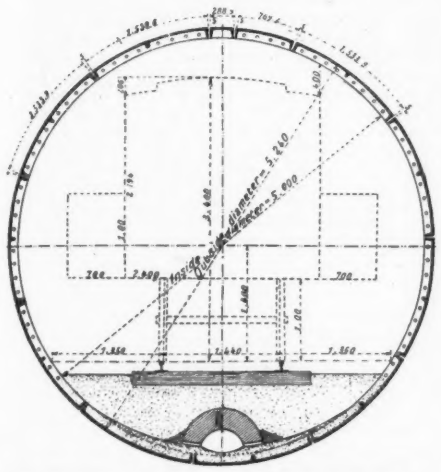


Fig. 15—SECTION OF TUNNEL UNDER THE SEINE

the full amount, though ordinarily it is shared between them. It is delivered at 10,000 to 13,000 volts to two sub-stations, one not far from the Gare Montparnasse and the other near the Gare St. Lazarre. In each of these transformers of a total capacity of 6000 kilowatts has been installed. The working pressure is 600 volts. The three-wire system is employed, there being an overhead conductor, a third rail, and the running rails. There is a difference of pressure between the overhead wire and the running rails of 600 volts; and the same between the third rail and the running rails. The latter, therefore, form the central or third rail of the system. Each train is made up of two motor coaches, one of which takes its current from the overhead wire and the other from the third rail, so that if everything is working well the current flowing back to the sub-station along the running rails is practically nil, and chance of electrolysis is therefore minimised. The collector rail is of steel and of Vignoles section, weighing 58.44 lb. per yard run. The overhead wire is of hard drawn copper of 150 square mm. cross section. It is grooved and is suspended at points averaging 18 m. apart. The line is divided into sections and is fed from the sub-stations as follows:—

From the Montparnasse Sub-station:
1st Section.—From the Porte de Versailles to the Montparnasse Station.
2nd Section.—From the Montparnasse Station to the Place de la Concorde.
From the Gare St. Lazare to the Sub-station:
3rd Section.—From the Place de la Concorde to the Gare St. Lazare.
4th Section.—From the Gare St. Lazare to Notre-Dame-de-Lorette.

The collector rail corresponding to each of these stations is fed direct from the sub-station without any special arrangements and without feeders. The overhead wire, on the other hand, is supplied from a feeder which runs from end to end of the section. This can be broken at each station, so that any desired division can be cut entirely out of circuit.

The cost of the line is given as having been 4,900,000f. per kilom., of which 3,400,000f. were for the works below ground and 1,500,000f. for those above. This amounts, roughly, to £179 per yard run.

THE *Tramway and Railway World* states that the official tramway traffic returns of 64 of the principal undertakings of the United Kingdom for the week ending June 3rd amounted to £227,548, or £27,741 more than for the corresponding week last year, while the track mileage was 2528, or 64 more than for the corresponding week. The receipts were at the rate of £90 0s. 2d. per track mile, an increase of £8 18s. 5d. per mile as compared with last year. The figures for this year include the receipts for the Saturday preceding Whit-Sunday.

THE HORSESHOE DAM ON THE BOW RIVER, ALBERTA.

By Mr. A. S. DAWSON, Chief Engineer, Canadian Pacific Railway Irrigation Department.

THE Horseshoe Dam, on the Bow River, near Bassano, in Alberta, is a mammoth structure, which is attracting the attention of the engineering world all over the American continent. It is being built on the Bow River at a point locally known as Horseshoe Bend, about three miles south-west of Bassano, which is 83 miles east from Calgary, Alberta. The function of the dam is to divert water into the main canal of the eastern section of the Irrigation Block. At this point the ordinary low-water level is at elevation 2515.00. The elevation of the sills of the canal headgates is 2549.63, and it was desired to raise the water to give a depth of 11ft. above these sills, making normal water level at the dam 2560.63.

The dam is to be a composite structure, consisting of a long and high earthen embankment on the south bank of the river, and a reinforced concrete spillway in the existing river channel, connected at its northerly end with the canal headgates. Just above the site of the dam the river makes a long bend, in the shape of a horseshoe, which gives the locality its name. The dam is situated at the toe of the horseshoe. At this point the river is approximately 600ft. wide. The north or the left bank of the river has a narrow bench immediately at the water's edge and only a few feet above it, beyond which is a cut bank rising over 100ft. above the bed of the stream. The south or right bank has a gravel beach rising gradually until it forms a tongue between the two legs of the horseshoe. This tongue has a broad, flat top several hundred feet in width, and rises gradually to the general prairie elevation. The general elevation of the surface of this tongue near the river is about 25ft. above the bend of the stream. On the tongue an earth dam is now under construction, to which the spillway structure will be joined.

The earthen embankment will have a maximum height of about 45ft., a total length of about 7000ft., and at its highest point is 350ft. in width at the base. It will contain one million cubic yards. The wetted slope is to be at an angle of 4 to 1, the dry slope at an angle of 3 to 1, the top width 32ft., and there will be a freeboard of 9ft. above normal water level. Provision has been made for under drainage, and its upper slope will be paved either with boulder concrete or reinforced concrete slabs. The foundation of the earth portion consists of a deposit of river silt over coarse gravel and boulders, which in turn overlies dense blue clay. The spillway was designed to pass over its crest 100,000 cubic feet a second, without raising the surface of the pool above elevation 2562.63, or 13ft. over the crest, which required a free length of weir of about 600ft. To allow for end contraction, on account of the piers necessary to support the movable crest, an aggregate length of 650ft. between piers was decided on.

As the crest of the dam and the sills of the canal headgates were fixed at elevation 2549.63, the additional depth of 11ft. for which the canal was designed had to be maintained by some form of movable crest for the entire length of the spillway in order to pass extreme floods. This movable crest will be divided into twenty-four sections, and will be supported between piers giving 27ft. clear spans. These openings will be regulated by structural steel gates, either in the form of segmental Taintor gates or by "Stoney" sluices.

In the determination of the spacing of the buttresses due consideration was given to the effect upon the cost of construction, the time required to build the structure, and the limitations in length of the gates corresponding to the spacing of the buttresses, with the result that these are to be at 15ft. centres, with every second buttress carried up in the form of bridge piers, with clear spans of 27ft. Emergency gates will also be provided in case of necessary repairs having to be made to the main gates.

The spillway proper is to be a reinforced concrete structure of the so-called Ambursen type, consisting of a heavy floor built upon the bed of the stream, with suitable cut-off walls at its up-stream and down-stream edges, and upon this floor will be erected parallel buttresses of substantially triangular outline, having a slope on the up-stream edge of about 45 deg. Upon brackets, or haunches, projecting from the faces of the buttresses and parallel to the up-stream edges will be cast concrete slabs to form a deck, terminating at the top of the buttresses in a curved crest, and passing down over the down-stream edge of the buttresses in the form of an apron suitably curved to correspond as nearly as possible to the path of the overfall flood waters. In front of the dam the floor will be carried down stream a distance of about 90ft. to form a tumbling hearth.

In general the spillway has what is known as the ogee cross-section, which, as your readers will be aware, consists of constructing the down-stream face of the dam between the crest and the floor in the form of a reverse curve, the lower edge of this curve being tangent to the floor of the structure, so that the overfalling water should be led down the face of the dam and turned into a horizontal direction tangential to the river bed with the least possible disturbance while passing over the face of the structure. The spillway is founded on a deposit of sand, gravel, and boulders, overlying a thick stratum of stiff, blue clay. At the upper and down-stream edges of the structure, as well as at the centre, heavy cut-off walls are being carried well down into the clay and well bonded to the body of the carpet.

The structure is to be 720ft. in length between abutments, with a maximum height of 40ft. to the overflow crest, above which 11ft. of water will be retained by the gates above referred to. It will contain about 40,000 cubic yards of concrete, and over 1100 tons of reinforcing steel. Provision will be made for a road bridge on the top of the structure. The abutments connecting the spillway with the earth dam will be in the form of reinforced concrete retaining walls of the counterfort type, with a view to cut off all possibility of leakage at this point. The method of operating the gates has not yet been decided upon, but it is probable that either a small power plant, consisting of vertical turbines with direct connected generators, will be installed inside the dam for this purpose, as well as for lighting, or else natural gas will be made use of.

The canal headgates will form an integral part of the spillway structure at its northerly end. They will consist of five openings, each of 20ft., and will be controlled by Stoney sluices. These gates will regulate the discharge through a main canal of 70ft. bed width, carrying 11ft. of water, and designed to discharge 3000 cubic feet per second. The material excavated from the first 13,000ft. of the canal, amounting to about one million yards, is now being transferred across the river over a double-track pile trestle bridge, and placed in the earthen embankment previously referred to.

The contract for this structure was let on October 1st, 1910, to the Ambursen Hydraulic Construction Company, of Boston and Montreal. Work was commenced immediately, and it is anticipated that it will be completed within eighteen months from that date. The earthen embankment is part of a large contract awarded to Janse, McDonnel and Co., in June, 1910, extending over five years, and including about 20 million cubic yards of excavation in the eastern section of the railway companys' irrigation block, in which close to half a million acres will be placed under "ditch."

We are enabled to give on page 646 a series of views showing the condition of the work in March of this year.

INLAND IRONWORKS.

BEYOND the shadow of a doubt, writes our Midland Correspondent, inland ironworks to-day are enormously handicapped. All the cry and all the fashion is "To the coast, to the coast." The increasing arrival from abroad of raw materials, whether in the shape of iron or partly manufactured steel, or what-not, and the necessity of getting the manufactured products to the ports for export at the least possible cost in the matter of handling and freight, both enforce the demand with a relentless insistence. The keenness of competition between rival works and rival districts at home, to say nothing of the pressure of international competition from without, seriously adds to the situation. If the statements of the chairmen of our public companies are to be received with entire credence, there never was a time when competition between home producers in the iron and steel trades—and it would be fair to say also in the constructive engineering trades, and some other of our heavy engineering branches, such as steam boiler building, &c., which might be mentioned—was a greater source of anxiety than at present. The fashion, or practice, in the establishment of new works now has quite changed from what we can remember. Unless under special circumstances, such, for example, as the necessity of going to a district where the labour for a particular industry exists in superior numbers or skill, or the strong desire to provide for the workmen garden-city surroundings, no board of directors would care to recommend their shareholders to lay down new establishments, seeking support from the export markets, and manufacturing heavy iron and steel or even heavy engineering materials in a land-locked part of the country. It is not too much to say that some of the heavy branches of the Midland and Staffordshire iron trades have reached a crisis in their existence arising out of this very matter. A month or so ago you had something to say respecting the iron trade and railway rates in this part of the kingdom, and additional information just to hand evidences that the more the question of inland iron and steel works is looked at, the less it is liked by capitalists and investors alike. There has just been offered for sale in the Black Country under the hammer a series of works comprising perhaps one of the most complete properties in any inland district in this country, and certainly in the Midlands, intended for the manufacture of black and galvanised iron and steel sheets, hoops, strips, and other merchant iron, the united concerns being valued at not far short of a total of £100,000. We are given to understand that curiosity ran high regarding the result of the sale. The properties might have been had for perhaps not very much over a third of their estimated value, yet, will it be believed, no sale of any one of them was effected, the bidding being far short of what was required. The event has had an important influence upon the views which Staffordshire ironmasters are forming of the trade outlook, and is regarded as another significant proof that iron and steel makers regard the seaboard as the spot to which all eyes must be turned, and where manufacturing capital must be invested if at all adequate profits are to be realised in future.

ROYAL SOCIETY OF ARTS' ALBERT MEDAL.—The Council of the Society, with the approval of his Royal Highness the President, the Duke of Connaught, have awarded the Albert Medal of the Society for the current year to the Hon. Charles A. Parsons, C.B., LL.D., D.Sc., F.R.S., for his experimental researches into the laws governing the efficient action of steam in engines of the turbine type; and for his invention of the reaction type of steam turbine and its practical applications to the generation of electricity, the ventilation of mines and other large spaces, blast-furnace work, ship propulsion and other important purposes.

THE SUPE-BARRANCA RAILWAY, PERU.—The Public Works Department of Peru has contracted with the Reparticion to Alpas Railway to extend the line of the Supe-Barranca Railway to Alpas. This extension, states the *Railway Gazette*, will connect the Alpas estate with the port of Supe. It will thus be an important factor in developing the surrounding country, and in affording more adequate facilities for transporting the increasing agricultural and stock-raising products of the fertile valleys of Barranca and Pativilca. The rich mines of the famous provinces of Cajatambo and Bolognesi will also find over this road a convenient, cheap, and rapid outlet for their mineral products, while the mining industry in the zones adjacent to the large territory penetrated by this extension will be so vigorously stimulated hat its rapid growth will be certain.

NEW PUMPING STATION AT WALTON.

No. II.*

WE concluded our first article by alluding to the fact that turbine-driven centrifugal pumps had been installed so as to take advantage of the difference in level between the Walton reservoirs and the Hampton filters, the pumps serving to pump more water into the reservoirs. The results achieved with these machines have, we understand, been most satisfactory. Arranged parallel to the main pumping engines, and on the same floor level, are three sets of combined turbines and centrifugal pumps, the former made by Gilbert Gilkes and Co., of Kendal, and the latter by Gwynnes, as sub-contractors to the Thames Ironworks Company. The turbines, which with the governing gear are illustrated in Figs. 7 and 8, are of the twin-horizontal

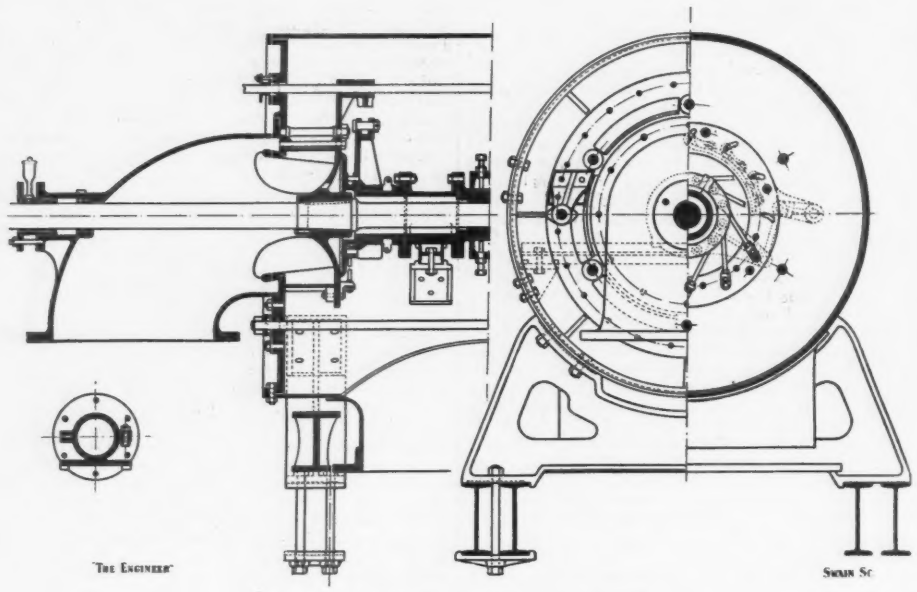


Fig. 7—150 HORSE-POWER LUNEDALE TURBINE

mixed flow type, called by their makers the Lunedale turbines, and are each designed to indicate 150 horse-power at 350 revolutions per minute. They are coupled to their pumps through flexible couplings similar to those used for the main pumps. The governing is brought about by means of deflecting blades, either actuated automatically by a centrifugal governor, or by hand-wheel through worm gearing. The pumps have 18in. suction and delivery pipes, and are each arranged to deliver approximately 10 million gallons of water in twenty-four hours to a head of 64ft. By the use of these it is possible to recover approximately one-third of the power employed in pumping water into the reservoirs, or, in other words, the main pumps will only have to work two-thirds of the time which would otherwise have been necessary had the turbine pumps not been installed.

A small calculation will show the extent of the saving which will be achieved. Supposing it is desired to lift 100,000,000 gallons of water in 24 hours to a height of 64ft. This represents some 1340 horse-power working continuously. A third of this is roughly 445 horse-power, or, say, 10,680 horse-power hours in the day. Engines, such as those at Walton, will, with their auxiliaries consume probably 1¼ lb. of coal per horse-power hour. The amount of coal saved per day therefore will be about 16,000 lb. If frictional and other losses be taken into account this figure will be considerably increased, probably by as much as 50 per cent. This would bring the saving to some 24,000 lb. of coal per day, or over 10½ tons. A saving of 10½ tons for each day that the station is working to its full extent is an economy which is well worth making.

All the pumps, whether main or turbine driven, are connected to two steel mains, supplied by Thos. Piggott and Sons, of Birmingham, which run parallel to one another from one end of the engine house to the other. Sluice valves are so arranged that any one of the pumps may deliver into either or both of these mains. In addition to these connections pipes are led off from the delivery side of the turbine driven pumps into the Chelsea reservoirs, which may be seen adjoining the pumping station in Fig. 1—page 616. The main pumps can also deliver into the Chelsea reservoirs if required.

The floor underneath the engine-house is reached by flights of steps constructed one at either end and one at the centre of the building. To describe all the arrangements on this floor would be impossible in the space at our disposal. There is a gallery running right round it from end to end and giving access to all the machinery installed at this level—the condensers, air pumps, sump pump, valves, &c. The latter are worked by hand wheels above the engine-house floor, but the gearing in connection with them is all on the lower level and all easily get-at-able. The suction valves of the pumps can also be reached from the lower floor.

Before leaving the engine-house we must not forget to mention the electrical arrangements. There are two steam-driven generating sets arranged side by side. The engines, made by Alley and Maclellan, have two cylinders, and are coupled direct to continuous current dynamos, which are wound to give 120 ampères at 210 volts at 400 revolutions per minute. The electricity is used for lighting and for working the motors for the coaling crane and conveyor, the ash hoist, and the

* No. I. appeared June 16th.

1800 square feet of heating surface, and has a grate area of 37.4 square feet. All are provided with chain grate mechanical stokers, to which the coal is supplied through shoots descending from overhead hoppers.

The coal supply is interesting. It is intended to obtain all the fuel used from barges moored at the river side adjoining the intake. Here there has been erected an electrically-worked transporter crane, the horizontal beam of which can be slewed so as to bring its end over a barge. The coal is lifted by means of a grab bucket which, when full, is raised and then propelled away from the river, until it comes over a hopper erected at one end of a continuous aerial overhead transporter system. In this system a series of skips is traversed along a continually travelling ropeway, supported on light steel uprights, and connecting the river terminus with bunkers arranged directly over the boilers in the boiler-house 500 yards or so away. The coal is delivered from the hopper, into which it has been dropped by the crane grab, into the skips one after another as they pass it. The skips then pass over a weighing machine which automatically records the amount of coal which has passed it. The motors for both crane and ropeway are driven by current generated in the engine-house. A telephone wire connects the pumping station with the riverside, so that not only may the supply of coal be regulated, but instructions given for the working of the sluices. The coaling crane was supplied by Babcock and Wilcox, and the aerial ropeway by Ropeways, Limited. The coal bunkers over the boilers have a capacity of 800 tons, and the coal is automatically dumped into whichever of the coal bunkers over the boilers may be selected, the empty skips then travelling along the return rope to the riverside. The chain grate stokers are worked by means of a small steam engine in duplicate, which is fixed at the floor level, and drives downward by chain on to a line of shafting carried under the floor of the boiler-house; chains driven by sprocket wheels with clutches connect to each of the stokers. The ashes as they fall from the boilers travel down shoots into wheeled skips, which run on a narrow-gauge tram-line laid in a gallery underneath the boilers. This line leads to an electrically worked hoist, by means of which the skips are raised to ground level, and may be wheeled away on a tram-line. At present it is not definitely decided in what manner the ashes will be disposed of. Perhaps the tram-line will be continued down to the river, so that the ashes may be shot into lighters for removal.

Each boiler is fitted with a superheater capable of giving superheat of from 120 deg. Fah. to 150 deg. Fah. to steam at 200 lb. pressure per square inch. Two Green's economisers are also installed at the back of the boilers, in the main flues, by-pass dampers being fitted to divert the hot gases through the economisers, or directly into the main flue leading to the chimney shaft. The scrapers are driven through chain gearing by means of a small steam engine. There are four pumps, either of which can be used as feed pumps, though some are used for other purposes.

It may be added that the boilers, steam receivers, steam piping, &c., in the boiler-house were supplied by Babcock and Wilcox, Limited. The magnesia non-conducting covering, and the planished steel lagging in the boiler-house were supplied by Hobdell, Way and Co., of the Minories, E., while the planished steel lagging on the engines in the engine-house was supplied by B. Robinson and Sons, of Bolton. A word of praise should certainly be said for the lagging, whether in engine or boiler-house. Throughout it is excellent, and looks most effective.

The water used in the boilers is passed through a large water softener supplied by Lassen and Hjort. This is erected outside the building close to the chimney shown in Fig. 10, which gives a general plan of the pumping station. With regard to size, we may say that the boiler-house is 131ft. long and 57ft. 6in. wide. The general arrangement of the boilers, economisers, and chimney is also seen in Fig. 10, as well as the relative positions of the various engines in the engine-house to which allusion has already been made. The cross-section of the buildings given in Fig. 9 makes these still more clear, and also indicates the positions of the coal bunkers over the boilers and the way coal is conveyed over them. It also shows the suction pipes from the pumps.

A few words may now be said with reference to the various adjuncts of the building. First of all may be mentioned the fitting shop and stores. The first measures 57ft. 6in. by 40ft., and it is divided from the boiler-house by two stores, 28ft. by 16ft. 6in. and 23ft. 3in. by 16ft. 6in. respectively. All these three rooms are provided with

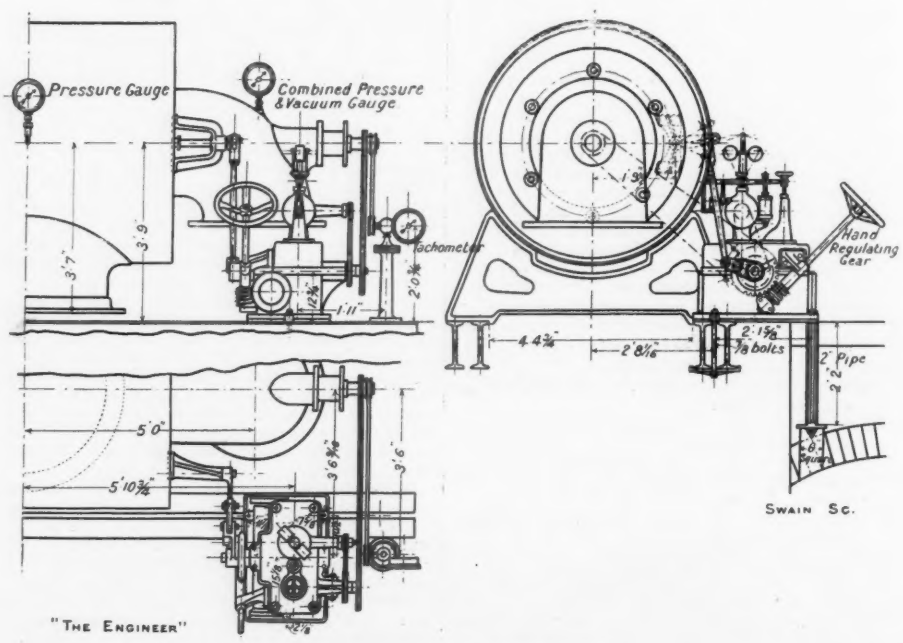


Fig. 8—GOVERNOR GEAR OF TURBINE

wood pavement. Lavatory arrangements and a bath for the use of the staff are also fitted, and in connection with these there is a circular cesspit, formed first of all by a 12in. puddle wall, inside which there is a 9in. ring of concrete, and inside again an 18in. brickwork ring. The cesspit is 8ft. in diameter. Detached from the main structure there is a small brick building for containing the measuring instruments for checking and recording the quantity of water passing through the various pipes.

The arrangement of the piping is noteworthy. First of all a pair of steel mains 54in. in diameter are run underneath the floor in the engine-house. Any one of

NEW PUMPING STATION AT WALTON-ON-THAMES

(For description see page 640)

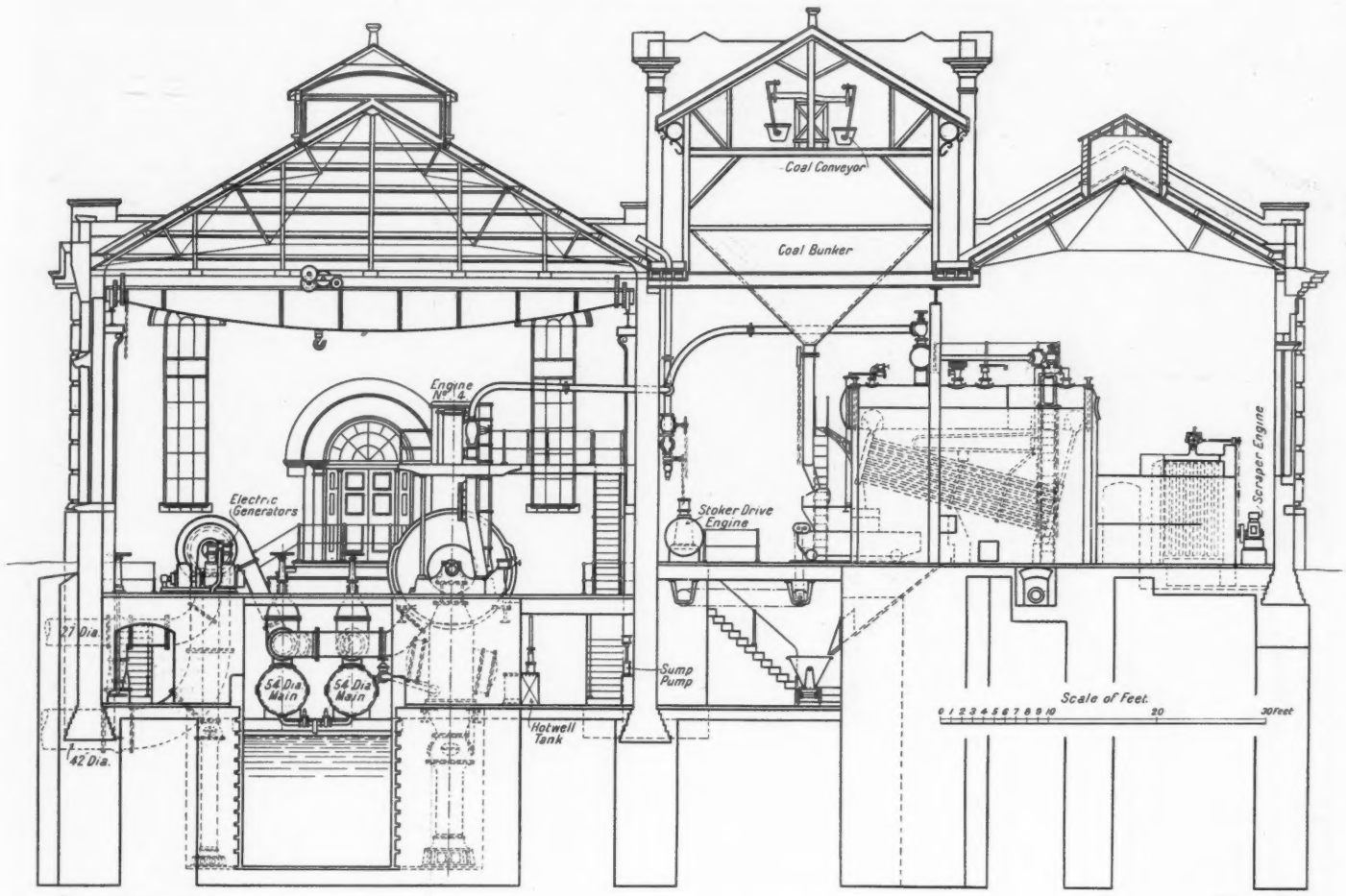


Fig. 9—CROSS SECTION THROUGH ENGINE AND BOILER HOUSES

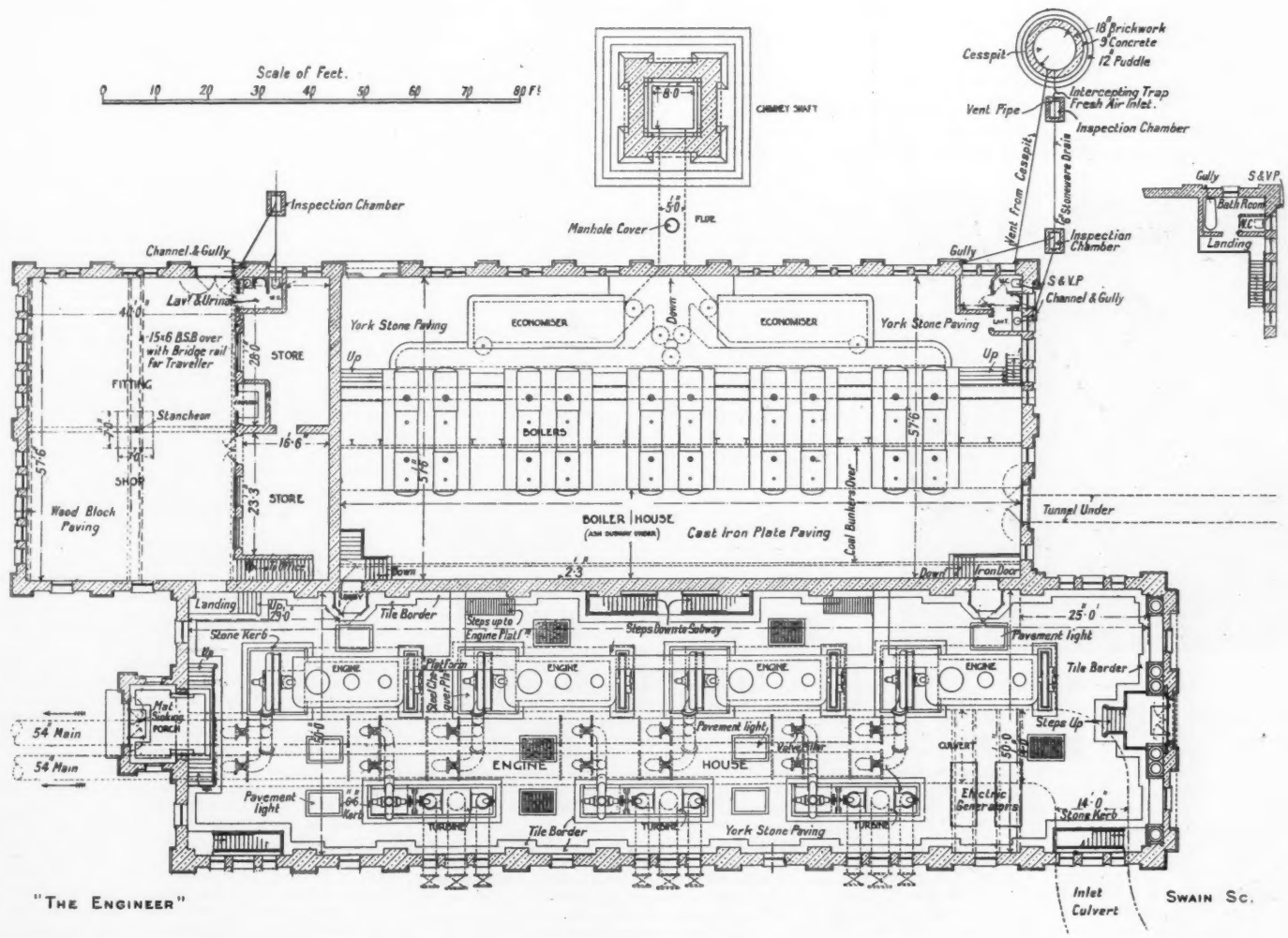


Fig. 10—GENERAL PLAN

the engines can deliver into either of these pipes. The pipe connections where these mains make their exit from the building are shown in Fig. 11. At first sight this looks a maze of pipes, &c., and most intricate. But it may be readily understood by studying it. First of all two 54in. cast iron branches are led straight away to the western of the two Walton reservoirs. These can be used separately or both at once, and are only intended for the purpose of conveying water to the reservoir. They may be seen to the left of the engraving, and are, of course, provided with a 54in. valve apiece. With the other mains practically every other conceivable combination can be made. First of all there are two 48in. mains carried direct to the Stanton Ironworks Company, near Nottingham, and some of the sluice valves by J. Blakeborough and Sons, of Brighouse, and the remainder by Glenfield and Kennedy, of Kilmarnock.

In order that it may be certain that the water shall remain in the two Walton reservoirs for the maximum possible period, arrangements have been made by which it is delivered at the western end of the western reservoir. Connection is at present made between the two reservoirs through their respective water towers, and the water is transferred by these from the eastward side of the western reservoir to the westward side of the eastern reservoir. The water is drawn off from the eastward side of the

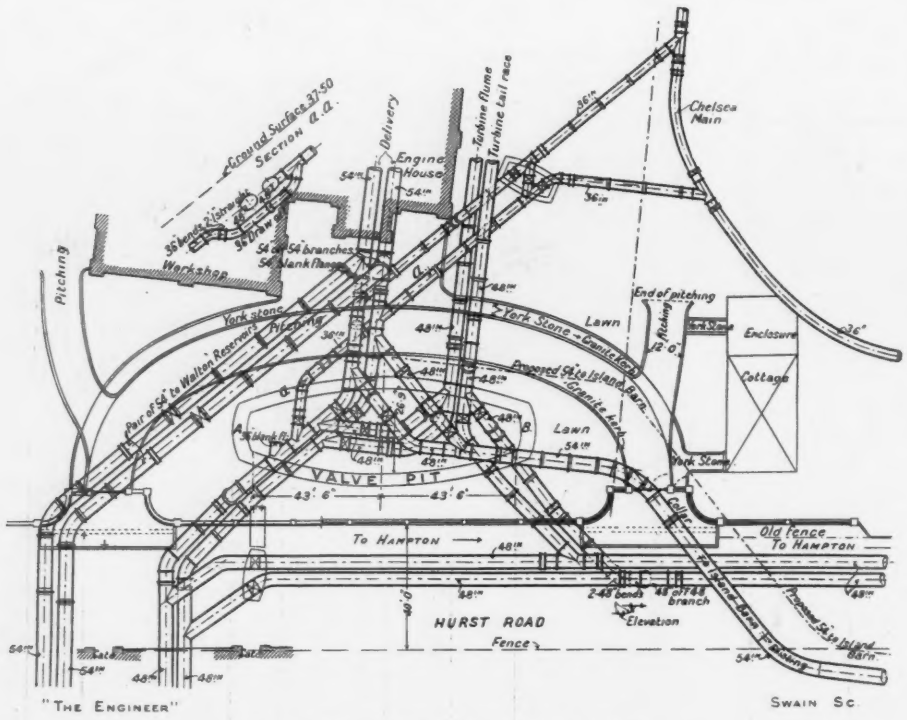


Fig. 11—ARRANGEMENT OF MAINS AND VALVES

the reservoir. Before they reach the latter they are provided with branches to two 48in. mains running to Hampton and are connected to these through valves. The former pipes may either be used for (1) filling the reservoir, (2) drawing off from the reservoir, or (3) one may be used for filling and one for drawing off. Both are connected by means of valves and 48in. mains to a 48in. main or flume running to the turbine pumps. The discharge from the turbines is through a 48in. tail race or flume, which, by means of two connections and valves, makes junctions with the 48in. mains running to Hampton. There are also junction pipes 36in. in diameter making connection with the Chelsea 36in. main, as may be seen in the right-hand top corner of the engraving.

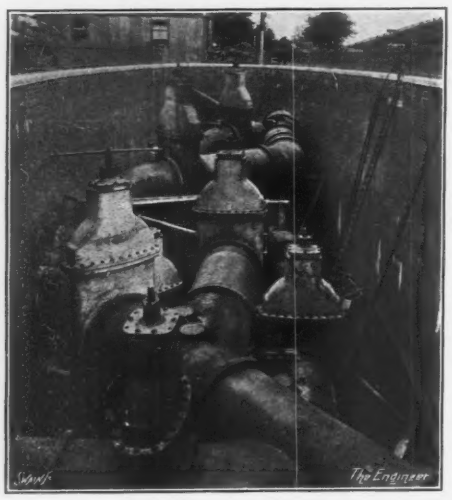


Fig. 12—THE VALVE PIT

All these connections may be readily traced. The reason for so much crossing of the pipes was in order to bring as many valves as possible into the valve pit, so that they might be the more readily accessible and manipulated. It should be understood that saving where they come within the oval between the letters A B they are all underground. It is intended to work all the valves in this valve pit A B by means of an electric motor, but this is not yet done. The principle on which it is to be carried out is, we understand, by means of a horizontal shaft running the full length of the pit at ground level. From this connections would be taken by means of shafting work by spur gear to the vertical spindles of each of the valves. It may be added that all the cast iron mains have been supplied by eastern reservoir, so that before it is passed away to the filter beds it has had to travel from the far end of one reservoir to the far end of the other. It is, we believe, intended ultimately to form two direct 54in. connections from one reservoir to another through the dividing wall, so that water could be passed from one to the other without passing through the valve towers.

Besides those illustrations to which we have made special mention, we may just refer to the remainder. Fig. 13 shows a view along the the culvert, which was described in the first portion of this article. The view is taken from just near the intake, and in the distance may be seen the pumping station with its chimney and a portion of the overhead coal conveyor. Fig. 14 is a general view of the station looking towards the river. To the right in the distance may be seen the culvert, while in front of the building is the valve pit to which we have just alluded. This view is taken looking down from the embankment of the Eastern Walton reservoir. A separate view looking down into the valve pit is given in Fig. 12. The two engravings - Figs. 15 and 16—show the electric generators and the switchboard.

In conclusion, we desire to express our thanks to Mr. Restler for the facilities he has given us in preparing this article as well as for the drawings, photographs, and particulars which he has put at our disposal. We also desire to thank the various members of his staff with whom we had the pleasure of coming in contact for the valuable assistance they afforded us.

BOOSTERS.

No. X.*

IN concluding this series of articles a few remarks may be made concerning the employment of static boosters for reducing the pressure drop in the return rails of alternating current traction systems. In the first article, appearing in our issue of March 10th, reference was made to the use of continuous current boosters for this purpose, and it was mentioned that their function is to suck back the current to the sub-station or power-house and to keep the pressure drop within the limits prescribed by the Board of Trade. Continuous current track boosters afford a means of overcoming troubles due to electrolysis, for by reducing the pressure drop along the return rails they prevent stray current from passing through water and other pipes buried in the ground. When the supply is an alternating one electrolysis is less troublesome, but it is not entirely absent, as is frequently supposed. With an alternating current traction system, however, in which the rails are used for the return, stray currents are liable to give rise to considerable trouble with telegraphs and telephones, and, as a consequence, it is desirable that they should be eliminated as far as possible. To prevent stray currents it is obviously necessary to reduce the pressure drop in the rails in a similar manner to that mentioned in the first article, and this can be accomplished by using boosting transformers connected as shown in Fig. 64. Here, it will be observed, the primary of the transformer is connected in series with the overhead conductor, whilst the secondary is in series with one of the rails. The effect of connecting a boosting transformer in this manner is to transfer the impedance drop of the rails to the overhead conductor, and in this way stray currents are, to a large extent, eliminated.

With a given length of track and a given current, the impedance drop in the case of an alternating current system will be considerably greater than the drop measured over the same length of track of a continuous current system. This arises from inductance and from the fact that an alternating current flowing in a steel rail is confined to a thin skin of the metal. It will be noticed that with the secondary of the boosting trans-

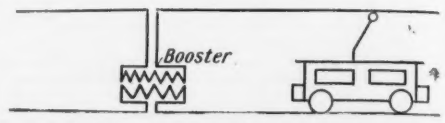


Fig. 64—CONNECTIONS FOR TRACK BOOSTER

former connected as shown in Fig. 64, it is necessary to divide the track at those places where the boosters are used, and that in this instance no separate return feeder is adopted. Stray currents in a continuous track, however, can be eliminated in a more effective manner by using a return feeder in conjunction with the rails, as shown in Fig. 65. Here we have a feeder running parallel with the track and connected in series with the secondaries of the boosting transformers, whilst tappings from the return feeder are connected to the track at various points. If the boosting transformers have a ratio of 1:1 the only difference between the primary and secondary current will be the very small current supplied by the primary side for magnetising the core. It is evident that by employing transformers in this manner and by connecting up the return cable at points near together on the track, the potential difference between any two points on the track may be reduced to any desired value. Since the impedance drop along the track is merely transferred to the overhead conductor, it may appear that it is neces-

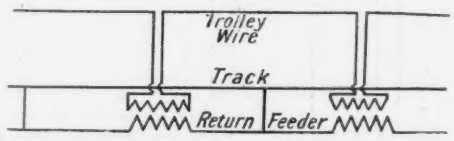


Fig. 65—TRACK BOOSTERS IN SERIES WITH RETURN FEEDER

sary to compensate the drop in the overhead wire with the aid of another booster.

It is to be remembered, however, that with the single-phase alternating current system variations in the pressure do not give rise to the same difficulties that are experienced with continuous current systems. In the case of the latter, when the controller handle is moved round to the last notch the full supply pressure is applied to the motors, and any drop that may occur in the conductors will give rise to a reduction in the speed of the train. With the alternating system, on the other hand, it is possible, by bringing out an additional tapping from the transformer on the train, to provide an extra notch on the control'er, so that when the handle of the latter is in the "full on" position the correct pressure is applied to the terminals of the motors. Thus the practice of transferring the impedance drop of the rail to the overhead conductor does not give rise to any diffi-

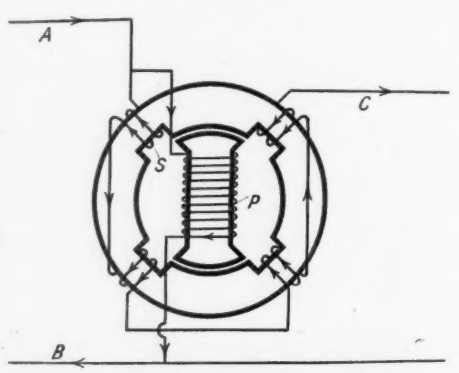


Fig. 66—SINGLE-PHASE INDUCTION REGULATOR

culty in the direction of maintaining the correct speed of the train. Although, as already stated, the magnetising current of the transformer is very small, it cannot be entirely neglected, and, as a result, the primary should have a few more turns than the secondary, and by connecting up the transformers, as shown in Fig. 65, the pressure drop can be reduced to a very small value between any two points on the rail, for the current will be drawn into the return cable.

Returning to the question of boosting alternating current feeders, a very convenient form of apparatus which may be used for this purpose is the induction regulator. These regulators allow of very fine adjustment of the pressure, and they are particularly well adapted for circuits working at high pressures. Regulators or boosters of this type are also frequently employed for changing the pressure at the slip rings of rotary converters, and for other purposes where a variation in the bus bar pressure

* No. IX. appeared June 9th.

NEW PUMPING STATION AT WALTON-ON-THAMES

(For description see page 640)

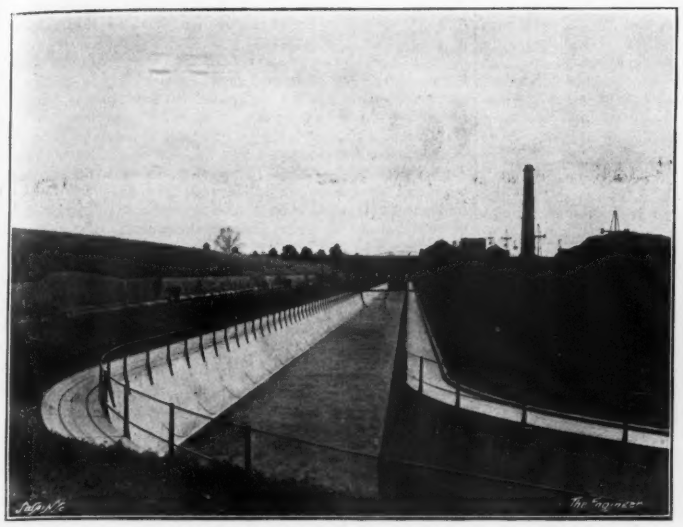


Fig. 13—LOOKING ALONG INTAKE CULVERT

Fig. 14 GENERAL VIEW OF THE STATION

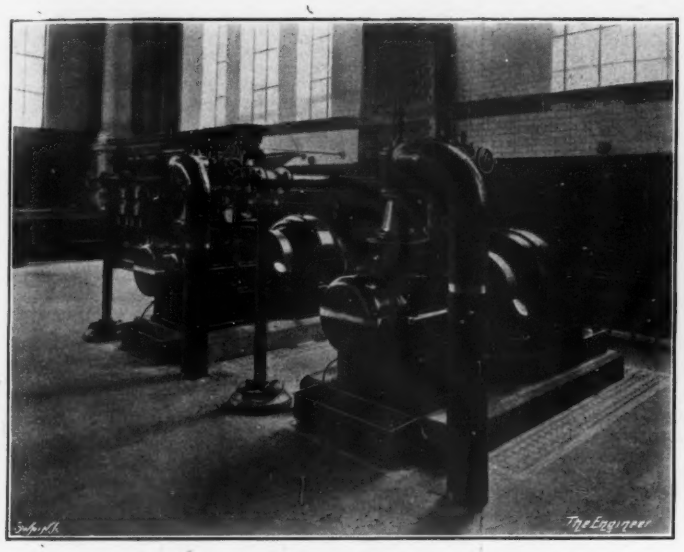


Fig. 15—STEAM DRIVEN ELECTRIC GENERATORS

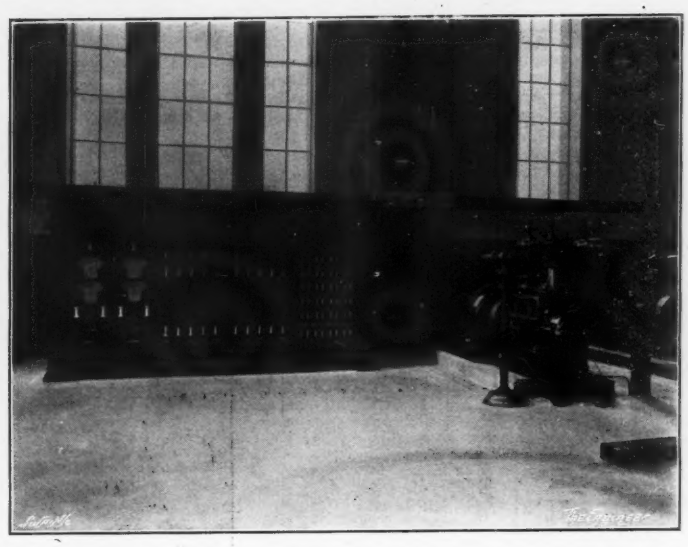


Fig. 16—THE ELECTRICAL SWITCHBOARD

is desired. In the induction regulator the whole of the primary and secondary windings are constantly in use, whereas in the transformer type of booster, with tappings brought out from the secondary windings, this only occurs when the apparatus is giving its maximum boost. Induction regulators are built in the single and polyphase types, and are frequently oil cooled. The regulator usually comprises two separate and distinct windings wound on concentric laminated iron cores, the primary or shunt winding being mounted on a vertical shaft, which can be partially rotated, and which is enclosed by and separated from the secondary or series winding by a small air gap. The principle of a single-phase induction regulator can be gathered from the illustration, Fig. 66. Here A and B are the mains connected to the generators; P is the primary winding of the regulator, which is connected across these mains; and S is the secondary, which is in series with the main A. The main C, therefore, is the high-pressure or boosted main. It is not difficult to see that when the primary is caused to take up different positions around the circle, the boosting effect of the series windings can be varied over a wide range. Having regard to the relative directions of the arrows on the windings, it will be understood that when the primary takes up the position shown in the diagram, Fig. 66, the electromotive force due to the secondary will be added to the pressure of the supply. By turning the primary through an angle of 90 deg. the electromotive forces due to the secondary windings on the two sides of the regulator oppose each other, and the boost is reduced to zero.

On moving the primary through another 90 degrees the voltages due to the four coils oppose that due to the supply and a negative boost results. Thus by placing the primary in intermediate positions any desired boosting voltage within the range of the apparatus can be secured and it is obvious that very fine regulation of the pressure becomes possible. A regulator constructed on these simple lines, however, has a fair amount of magnetic reluctance and leakage, and as a result it demands a large exciting current and has a considerable voltage drop. These disadvantages have been overcome by increasing the length of the polar arc and by winding a portion of the secondary on the movable iron core together with the secondary winding, but a regulator constructed on these lines does not represent the latest practice. The usual induction regulator is a special type of transformer built like an induction motor.

A secction of a modern single-phase induction regulator is shown in Fig. 67, where the secondary winding of the regulator is shown wound within certain slots of the fixed core and the primary winding, which, as shown in Fig. 66,

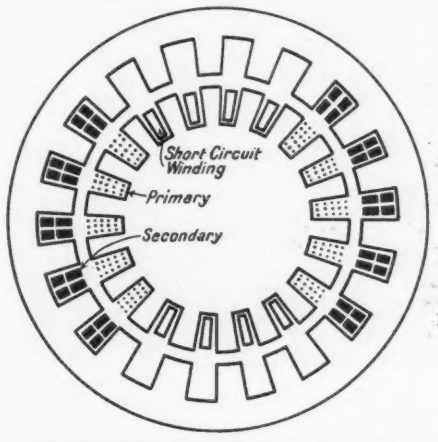


Fig. 67—SECTION OF INDUCTION REGULATOR

is connected across the mains and wound within slots on the movable core. It is evident that with a regulator designed on these lines the secondary may have the full load current when its electromotive force is zero, because the current in the secondary is dependent upon the generator pressure and the impedance of the external circuit. In consequence of this, when the movable core is in the position for giving a zero electromotive force, the magnetomotive force due to the secondary is not opposed by the primary current, and as a consequence a considerable flux interlinks with the secondary, and so sets up a considerable reactance therein. This difficulty, however, has been overcome by providing a short circuited winding on the movable core, as shown in Fig. 67.

It is easily seen that when the movable core, carrying the primary and short circuit windings, is in the positions for maximum positive or negative boosting voltages, the magnetomotive force due to the secondary is

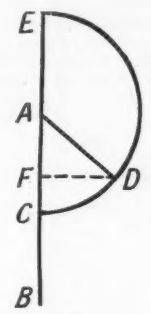


Fig. 68

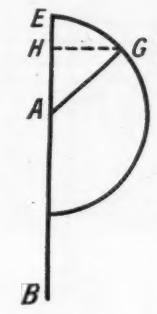


Fig. 69

directly opposed by the primary magnetomotive force, and no current is produced in the short circuited windings. At other positions the secondary magnetomotive force is partly opposed by the primary and partly by the short-circuited winding, the resultant of the two magnetomotive forces being equal to the secondary magnetomotive force. In this way the reactance of the secondary is reduced to that due to magnetic leakage between the fixed and moving elements. The voltage due to the secondary of a single-phase induction regulator is always in phase or in opposition to the voltage in the primary, and, as a consequence, the

resultant secondary voltage is equal to the sum or difference of the primary and secondary voltages. This will be readily understood by reference to the diagrams, Figs. 68 and 69. Let A B, Fig. 68, represent the electromotive force of the primary coil, and A C or A E the positive or negative boosting voltage, depending upon the position of the movable core carrying the primary winding. If, then, the line A E also represents the position of the movable member when the full boosting pressure is added to the supply or primary pressure, then A C will be the position of the movable core when the booster is developing its maximum pressure in opposition to that due to the supply. Now, suppose that the axis of the movable core has taken up the position A D, as in Fig. 68, then the value of the secondary pressure will be A F. This pressure is in opposition to the supply

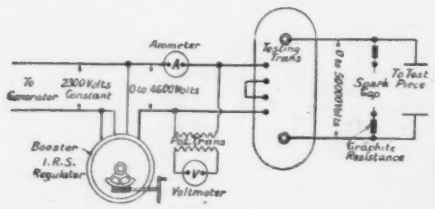


Fig. 70
INDUCTION REGULATOR FOR HIGH POTENTIAL TESTING

pressure, and the resultant is F B. With the axis of the moving core in the position A G—Fig. 69—the secondary voltage is A H and the resultant pressure is B H.

The illustration, Fig. 70, shows how a single-phase induction regulator may be used in conjunction with a transformer for high potential testing. It will be gathered that by shifting the position of the movable element, the pressure due to the regulator can be made to assist or oppose the pressure due to the supply, and in this way the voltage at the testing point, that is on the secondary side of the high-pressure transformer, can be gradually increased from zero up to the maximum value. The General Electric Company of America supplies induction regulators both for single and polyphase working and for hand or automatic operation. The diagram of connections, Fig. 71, shows the method adopted for automatically changing the position of the movable member of a single-phase

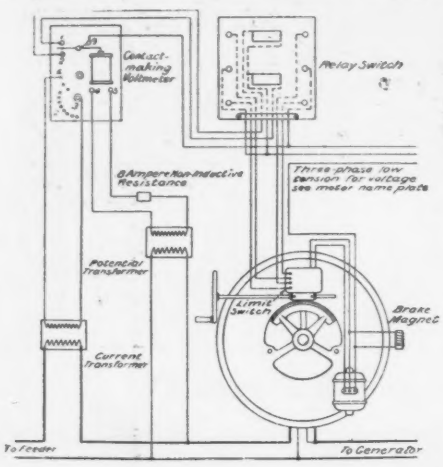


Fig. 71
AUTOMATICALLY CONTROLLED INDUCTION REGULATOR

induction regulator. The automatic operation is effected by an auxiliary contact making voltmeter, so connected to a potential and current transformer that a rise or fall of the line voltage from a predetermined value will cause contact to be made in a relay switch, this in turn closing the circuit of a small motor which is mounted directly on top of the regulator case, and which drives the regulator armature through the medium of gearing. The regulator, as already explained, comprises two separate and distinct windings arranged on concentric laminated iron cores, the primary or shunt winding being rotated by means of the motor. The shunt winding produces a magnetic flux that has a constant value, the direction of which is fixed with relation to the movable core, but variable with respect to the secondary core, and consequently with respect to

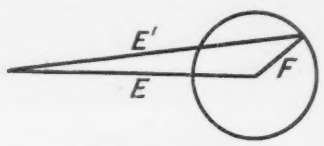


Fig. 72—VOLTAGE DIAGRAM

the series or stationary winding. The windings are encased in a rectangular corrugated cast iron tank which is filled with oil up to the level of the windings. The design permits of a free circulation of the oil, and the corrugated tank easily radiates the heat. All the operating mechanism, with the exception of the contact-making voltmeter and relay, is mounted on the cover. The relay and contact-making voltmeter can be placed in any convenient position. This regulator will give a gradual increase or decrease of voltage in accordance with the requirements of the feeder, and its operation is said to be rapid enough to control the pressure at the end of a feeder which is carrying a widely fluctuating load.

So far as the general construction is concerned the polyphase induction regulator closely resembles the polyphase induction motor. As in the case of the single-phase apparatus it has fixed and movable cores on which the polyphase windings are wound. The primary winding is connected across the supply, and the secondary windings are in series with the three-phase cables constituting the circuit it is required to boost. On connecting the primary windings to the supply an electromotive force is generated in the secondary winding, and the value of this pressure is independent of the position of the movable member. The phase of the secondary pressure in relation to the primary pressure, however, changes with the position of the movable element, and as a consequence it becomes possible to vary the boosting pressure.

Fig. 73—SIEMENS' INDUCTION REGULATOR

Suppose that a polyphase induction regulator is used for varying the pressure at the slip rings of a rotary converter. Then in the vector diagram—Fig. 72—let the line E represent the electromotive force of the source, *i.e.*, the pressure at the transformer, and suppose the line F represents the pressure due to the secondary of the induction regulator, then E^1 will represent the pressure supplied to the slip rings. The position of the vector F depends on the position to which the rotor is set, so that the voltage at the slip rings represented by E^1 may be made larger or smaller than E. It will be seen that no matter what position the movable member has, the value of the booster's pressure can always be represented by the radius of the circle, but the phase of this pressure can be altered by turning the movable member. Thus, whilst in the case of a single-phase regulator the resultant

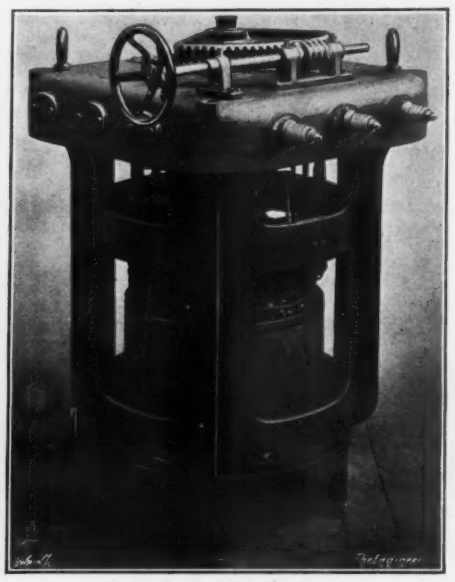


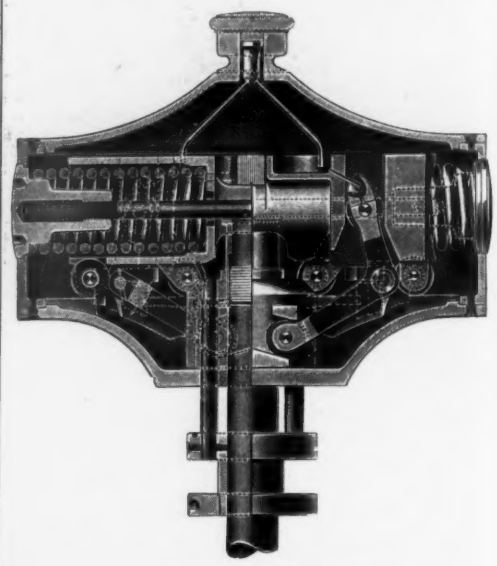
Fig. 74—SIEMENS' INDUCTION REGULATOR

pressure is equal to the arithmetical sum or difference of the primary and secondary electromotive forces, the resultant pressure in the case of a three-phase regulator is the vector sum or difference between the primary and secondary pressures. It is easy to see that the net pressure represented by E^1 in Fig. 72 can be made to vary considerably by changing the position of the movable member. The reason for the resultant pressure being the vector sum of the two other pressures in the case of a polyphase induction regulator is that a revolving field is produced by the polyphase windings of the primary. If we assume the revolving field to have a constant strength, then the phase of the electromotive force set up in any conductor under the influence of this field will vary with its relative electrical position. Thus, since in Fig. 72 the primary voltage is represented by E, and the secondary voltage by F, it follows that the resultant pressure must be E^1 both in value and relative phase position with respect to the primary electromotive force. It has been found unnecessary to provide polyphase induction regulators with short-circuited windings on the primary member, because the magnetomotive force of the current in any of the secondary windings in any position is always balanced by the magnetomotive force due to the primary, and as a consequence the reactance of the secondary is merely dependent upon the magnetic leakage between the fixed and movable members. The illustrations—Figs. 73 and 74—show a 60-kilo volt-ampère three-phase induction regulator built by Siemens Brothers, of Caxton House, Westminster, S.W. It will be gathered that this is an oil-cooled regulator of the hand-operated type.

A NEW GOVERNOR.

A NEW governor, which has been designed with a view to satisfying the stringent demands which are frequently met with in specifications under the heading of regulating guarantees, and which is suitable for steam engines, turbines, and gas engines, has been brought to our notice by the firm of Jens Orten Böving and Co., of 9½ Union-court, Old Broad-street, E.C. It differs in a number of respects from the other governors, and possesses features for which advantages are claimed. From the accompanying illustration it will be gathered that small rollers are employed in conjunction with the various moving parts, and as a consequence friction is reduced to a minimum. It is pointed out that the reduction in friction brought about by the employment of these rollers greatly increases the sensitiveness in working.

The whole of the mechanism is enclosed in a polished cast iron casing which is oil-tight. This casing is composed of three parts, the base, the cover, and the cylindrical portion, which fits in between the two first-mentioned parts, and closes in the working mechanism on all sides. By dividing the casing into three the construction is simplified, and should any of the working parts need turning, this arrangement enables them readily to be removed. The tapered end of the governor shaft is fixed into the bottom of the casing and held in position by a nut. The revolving masses, which are of cast iron, move in straight lines, their weight being



ENGINE GOVERNOR

taken by two steel rollers. The surfaces on which the rollers work are of specially prepared steel. The sleeve, it will be noticed, is in two parts, the upper part being connected to the section beneath it by means of small rods. The upper part, which is situated inside the governor casing, works on a cylindrical boss, which is part of the governor base. For the purpose of keeping the springs in position a long bolt is provided, at the end of which there are two lock nuts. To avoid the possibility of the bolt working loose a pin is inserted through this and the governor shaft. Rubber rings are fitted where necessary to prevent any oil from working out. The lower portions of the mechanism are immersed in an oil bath, whilst lubrication of the rollers working inside the weights is effected through the cap on top of the governor.

We are informed that several of the leading steam turbine builders have adopted these governors, and that they are fitted to the Howden turbines erected in the Horseferry-road power station of the Westminster Electricity Supply Corporation.

THE plans of the Metropolitan District Railway Company for the alteration of the Temple station have received the approval of the London County Council. According to the *Railway Times*, these plans show revised elevations for the reconstruction and enlargement of the station authorised by the Company's Act of 1910. The elevation to the Norfolk-street approach is to be constructed of Portland stone, as provided in the Act. The new plans provided for a restaurant, and the company have asked the opinion of the Council as to the possibility of using the station roof as a tea garden, from which there would be an interesting view of the Thames. The Parks and Open Spaces Committee have not, however, yet dealt with the matter. The Council at its last meeting deferred an expression of opinion.

RAILWAY MATTERS.

H.M. CONSUL at Boma reports that a scheme is on foot for building an electric railway from Matadi to the neighbouring hills, to enable the Europeans to live out of the town, where the climate is excessively hot.

H.M. LEGATION at Christiania report that the Norwegian Government proposes to proceed at once with a line connecting the existing railway up the Gudbrandsdal with Trondhjem, and gradually to convert the existing narrow gauge lines to broad gauge, and to extend the lines to important commercial centres.

THE longest regular locomotive run without a stop in Germany is now between Berlin and Hamburg, 178 miles. This is made by two trains daily, one in 3 hours 20 minutes and one in 3 hours 22 minutes. The longest locomotive run without a stop in France is 163 miles. The longest run without a stop in England is 226 miles.

SUCCESSFUL experiments in the use of crude oil on the locomotives on the Canadian Pacific Railway between Vancouver and Kamloops have decided the vice-president, Mr. William Whyte, to recommend the use of oil as fuel for the entire distance through the mountains. It is believed the adoption of this course will remove the danger of conflagrations in the great forest areas of British Columbia.

EXPERIENCE with creosoted trestles on the Illinois Central Railway has shown that there is less danger of their catching fire from sparks than is the case with structures of unprotected and defective timber. This is considered to be due to the sound surface presented to the spark, which does not ignite readily. A fire once started in a creosoted structure is much more fierce, however.

ACCORDING to the *Railway Gazette*, the Anatolian Railway, the western terminus of which is opposite Constantinople, has contracted with a great petroleum company of Roumania for supplying its locomotives with oil. The oil will be delivered by vessels at the railway terminus. The change of the locomotives from coal burning to oil burning will be made twenty-five at a time, and will begin immediately.

TIMBER trestles on the coast extension of the Chicago, Milwaukee and St. Paul Railway, are in many cases protected against fire from coals dropped by the locomotives by a covering of gravel over the sleepers between the tracks. Board strips are placed between the sleepers, blocked up above the stringers, and the gravel then laid on the sleepers and boards. This filling requires occasional attention on account of the tendency of the gravel to work to one side or the other.

THE *Official Messenger*, St. Petersburg, states that a project has been laid before the Russian Minister of Finance for the establishment of a company to construct and work small lines of railway to the stations of the State lines, to act as feeders to the latter. The company would also undertake the construction of lines for private enterprises. The capital proposed is 2,500,000 roubles (about £264,000). The project has been approved in principle by an inter-departmental commission. It has next to go before the second department of the Council of the Empire.

WE understand from our contemporary, the *Electric Railway Journal*, that the Public Service Commission of New York Second District has ordered that a return is to be made by the steam railway companies of all delays occurring to passenger trains in the State. An average of 54,216 trains per month was run in the year ending March 31st, 1909. The number was 58,651½ the succeeding year, and in the year ending March 31st, 1911, it had increased to 63,236. The report to the Commission showed that 83.4 per cent. was the average for trains on time in these three years.

THE routes in Leeds and Bradford which have been created for the new form of railless trolley traction were examined on Monday, June 19th, by an inspector of the Board of Trade, Major Pringle. The examination of the running and general equipment of the vehicles passed off very satisfactorily, and the formal announcement from the Board of Trade giving permission for the system being used for public service is now being awaited. The interval will be utilised in familiarising the motor-men in driving the cars. It is not anticipated, however, that many days will elapse before the system will be available for public use.

ELECTRIFICATION of the railways entering Boston is likely to be favoured by the Massachusetts Legislature. The Committee on Railways and Metropolitan Affairs on May 25th voted 14 to 12 for a measure which provides that all the standard-gauge railways within the metropolitan district shall be electrified in such manner and such order as the Board of Railway Commissioners may determine. The railways are to file plans and specifications for electrification with the Railway Commission before September 1st, 1912. The Commission is to determine the extent to which public necessity demands electrification and will fix a date for beginning the work.

IN a parliamentary White Paper issued this month the Under-Secretary of State for India shows the financial position in respect of Indian railways in course of construction and likely to be undertaken during 1911-12. The total length of the railways is given as 3047 miles, of which 585 miles are new lines and 2462 miles lines in progress. Of the new lines 279 miles are in the hands of the State and 306 miles in the hands of companies, while of the lines in progress 591 miles are in the hands of the State and 1871 miles under the control of companies. The estimated total cost is Rs. 27,30,55,000, the proposed expenditure in 1911-12 Rs. 6,12,15,000, and the estimated liability on March 31st, 1912, Rs. 11,75,06,000.

A WHITE Paper recently issued contains appendices to the final report of the Royal Commission on the Canals and Inland Navigations in the United Kingdom, in which the inland waterways of Ireland were dealt with. In an appendix giving comparisons between English and Irish railways it is stated that, while Ireland has a little more than half the area of England and Wales, it has only about one-fifth of the mileage of railway, and that, while the mileage in Ireland is .10 miles of railway per square mile, in England it is .27 miles per square mile. On the other hand, Ireland has .75 miles of railway per 1000 inhabitants, while England has only .49 miles per 1000 inhabitants. The total tonnage carried in England and Wales in 1908 by railway amounted to 419,632,279 tons, while in Ireland all the railways only carried 6,005,369 tons.

THE assistant chief engineer of the Szechwan-Hupeh Railway, China, states that 50,000 coolies are now at work on this line. Eighty-five pound rails are employed for the main line, using 13 sleepers to the rail. Construction trains are running twice daily between the Ichang wharf and the track end, a distance of about six miles. More than 40 ballast cars are now in use, carrying materials. With the exception of two cuts, the track could be laid some 20 miles. The Ichang station building is finished up to the roofing, and will be soon completed. The three store rooms are already occupied, the locomotive sheds built, and the head office building fairly started. Near the station are two 22ft. wells, while the water tower will soon be completed. The coal yard is under construction. Four shafts have been sunk at the 6200ft. tunnel, 50 miles from Ichang. The presence of water renders the work difficult. Two 1000ft. tunnels are under way, 25 miles from Ichang, and one 700ft. long, about 15 miles from that city, is completed. The equipment for the machine shop, ordered from a German firm, has arrived and will shortly be erected in the newly built workshop.

NOTES AND MEMORANDA.

WATER consumption at Springfield, Mass., a city of 88,926 population, averaged 119 gallons per inhabitant daily during 1910 Mr. Albert E. Lockridge, chief engineer, states in his last annual report that 45 35 per cent. of the consumption is metered.

LAST year there were 250 gasworks and 7127 electricity supply stations in Italy; 5148 of the latter only supplied private plants. The total gas consumption was 8180 million cubic feet, and the total electricity consumption 113 million kilowatt hours. The electricity consumption increased 18 per cent. over that of the previous year.

A REINFORCED concrete ice house was recently erected in Philadelphia with sheet cork as the insulation throughout, instead of wood and mill shavings, sawdust, and the like, which have generally been used. The insulation of the ceiling consists of 3in. cork boards, attached with cement to the under side of the reinforced concrete slab. The walls are insulated with two layers of 2in. cork boards, with all joints broken, and the floors with two layers, laid in hot asphalt on a concrete base. The finish on the sheet cork and walls and ceiling is Portland cement; for the floor finish a concrete and cement floor is laid directly on the cork.

AT a meeting of the Royal Meteorological Society Mr. Spencer C. Russell described how he obtained records of the actual size of raindrops. He said the experiments had led him to conclude that the most satisfactory results were given by the use of plaster of Paris or fine flour placed in 3in. shallow trays to a depth of 1½in. Raindrops during six thunderstorms had been registered, yielding a total of 164 drops, divided up into the following sizes:—Twenty-five of 5 mm., 40 of 4 mm., 48 of 3 mm., 35 of 2 mm., and 15 of 1 mm. The largest drops occurred at the commencement of the storm, grading off as the storm progressed. Before a fall of hail a marked increase in drop size was apparent.

AN article in a French contemporary refers to the advantages of low-tension metallic filament lamps and the use of a step-down transformer on alternating-current lighting circuits. A drawback is that these transformers are inefficient on light load and the low power factor is an inconvenience. To avoid this it has been suggested that sufficient lamps to load the transformer fully should always be applied and that lamps and transformer should be switched on and off together; but this limitation is unsatisfactory. The author therefore suggests the use of a small condenser in parallel with the transformer serving the house He mentions a case in which a power factor of 0.67 was improved to 0 9 by the use of a condenser of 1.37 mfd. and a lagging current was converted into a slightly leading one. An improvement of 2 3 per cent. in the full-load efficiency was also obtained as a result.

PRESSURES of 100,000 and more are usually carried by overhead wires now-a-days, but the voltage of underground cables is usually restricted to a maximum of 10,000 volts. It is true that in Germany there are a few 20,000-volt cables, and at least one of 30,000 volts. This, however, is exceptional, and the reason, of course, is that it is cheaper to carry very high-tension currents overhead. It must not be forgotten, however, that they are more dangerous than underground cables. Storms, accidents to buildings, and other causes may bring the overhead wires down, with terrible results, both from the mechanical action of the broken wire and from the electricity. The difficulty with underground cables is, of course, the insulation. The overhead wires are insulated by the air—an insulation of variable power, it is true, but far superior to most others, even under the most adverse circumstances of moisture and heat.

NOT very long ago it was discovered that ramie was much more effective in the construction of incandescent gas mantles than cotton, for whereas in the case of cotton the separate fibres of the yarn employed are closely entangled, in ramie they remain pretty wide apart, and so present a larger glowing surface. Now it is reported that experiments with artificial silk show that the fibres of this material maintain their individuality to an even greater extent than ramie, and the mantles themselves are said to be much more elastic, supple, and durable. The Deutsche Gasglühlicht Company of Berlin has been doing a good deal of research work on these lines, and it is said that it intends shortly to place a new mantle on the market, whose essential difference from existing types lies in the fact that it is made of artificial silk. It is claimed for it that it is specially adapted for street lighting, and for all purposes where high-pressure gas is employed.

AN address was recently delivered by Prof. R. W. Wood, of the Johns Hopkins University, Baltimore, at the Royal Institution on experiments which he has carried out with "invisible light"—*i.e.*, portions of the spectrum which are incapable of exciting the retina. Using a quartz lens coated with silver, which is opaque to ordinary light, but transparent to ultra-violet rays, he was able to make a remarkable series of photographs of various objects, comparing them with photographs of the same objects made in the ordinary way. Objects which do not reflect ultra-violet rays come out black; a man standing in bright sunlight is found to cast no shadow when photographed by ultra-violet light, proving that the latter reaches the surface of the earth mainly by diffusion from the sky, not directly from the sun. The air surrounding an electric spark appears luminous by ultra-violet light, showing that some hitherto unknown radiation is given off. Photographs have also been made with the infra-red rays.

IN a paper on "The Self-discharge of Planté and Faure Storage Batteries," read before the American Electrochemical Society by Messrs. O. W. Brown and W. G. Bowers, the authors gave some data showing that the Planté type of cell loses its charge when allowed to remain on open circuit for periods of ten to twenty days. The Faure cell, when made from pure materials, suffered only very slight loss in capacity when left on open circuit. In every test the self-discharge of the Faure cell was much less than in cells of the Planté type. The data also showed that the Planté cell suffered permanent injury when considerable periods of time were allowed to elapse between the charges, while one or two recharges of a Faure cell restored it to its original capacity. In the light of these results, the Faure type of cell was, the authors considered, best suited for all service where intervals of a week to a month or more must elapse between charges. This condition was found in some telephone plants, in isolated lighting plants, and where cells were used for ignition purposes and for the operation of signal systems.

WRITING in the correspondence columns of an American contemporary, Mr. J. L. Fitzhugh describes how, after a number of experiments to protect its service pipes against electrolysis, the Laclede Gas Company, of St. Louis, is now covering its wrought iron piping with layers of pitch and paper. This method seems to be proving successful. The wrought iron pipe is first coated with a tar and pitch mixture, heated and thinned sufficiently to flow easily, and on to this a 4in. paper ribbon is wrapped spirally, its edges overlapping. This paper covering is then tar painted and again wrapped with paper, the process being repeated until four successive coats of tar and paper have been applied. Pieces of pipe thus insulated have been placed in the ground under conditions distinctly favourable to electrolysis, together with other lengths not so treated, and after being taken up at the end of two years, the unprotected pipes were badly pitted and almost completely destroyed, while the insulated piping was virtually in the same condition as when laid. It is believed that pipes so treated will have their life at least doubled. Only service runs are being so treated, the cast iron mains being less subject to corrosion and electrolysis than the service pipes. The tar and paper coating is very hard when cooled, and the pipe lengths need to be handled with no more care than bare pipe.

MISCELLANEA.

THERE has been placed before the Dominion Government a project for the development of electrical energy at Cedar Rapids, on the St. Lawrence River, at a cost of between £3,083,000 and £4,111,000. It is estimated that 500,000 horse-power can be developed.

TEMPERATURES in masonry dams in Great Britain are stated by Mr. Edward Sandeman, engineer of the Derwent Valley Water Board, to vary about 5 deg. at a distance of 30ft. in from the face, while at a depth of only an inch or so a variation of 70 deg. may be found.

THE Committee on Local Transportation of the Chicago City Council has held several conferences and public meetings to consider plans for the construction of public subways. In a proposal put forward by Mr. B. J. Arnold, the chief subway engineer of Chicago, he said that, according to his plans, the subways would take five years to complete, and the cost would be about £4 200,000.

IN view of the action taken by the Plymouth Chamber of Commerce during the chairmanship of Mr. Orlando Davis to induce the authorities to adopt submarine signalling, it is interesting to know that a bell buoy fitted with an automatic bell has been established about five cables west-south-west of the Bishop Rock Lighthouse. As the submarine bell will be actuated by the movement of the buoy, the number of strokes per minute will not be uniform. The approximate position of the bell is lat. 49.52.3 N., long. 6.27.13 W.

THERE are now several thousand cars in use in the island of Java, and the number is steadily increasing. Several new British makes have been introduced, and in all about 500 cars have been imported during the past year. Roads through the island are generally fair to good, and supplies of petrol and lubricants are obtainable in every town or village of any importance, as depôts have been established all over the island by the Java Motor Club. Motor bicycles are also coming into favour, and the trade in these vehicles is likely to increase.

A LARGE 2,300,000 lb. Emery testing machine is now being erected at the Washington laboratory of the Bureau of Standards, and some of the largest pieces have recently been put in place. The straining press, piston, and cylinder head were assembled and forwarded from the manufacturers in one piece, the shipping weight being 22½ tons. It was carried across the city on a heavy four-wheel truck, drawn by twenty-six horses, and at the grade on Massachusetts-avenue the number was increased to thirty. The machine is being erected in the engineering building.

ACCORDING to the *Electrician* the consumption of electricity for lighting at Bury shows an increase of over 12 per cent. after a depression, due to the introduction of the metallic filament lamps, lasting about two years. Another pleasant feature of the Bury engineer's report is the increase of 24 per cent. in the power load. During the year the tramcars were equipped with meters to check the amount of current used, and it is interesting to note that the current required for traction purposes fell by no less than 19.7 per cent. Even if other causes have contributed a little to this result, it is certainly a striking illustration of the economy of a proper system of checking consumption.

IT appears from a note in the columns of the *Electrical Review* that a system of wireless telegraphy is to be carried out in the Congo State, following the course of the Congo up to the Katanga district for a distance of 1860 miles; transmitting stations are to be erected in all the principal places. The apparatus of the Radio-Electrique as used in the French possessions will be employed in the neighbourhood of the French colonies, whilst the usual apparatus of the Telefunken Gesellschaft will be used in the vicinity of the German colonies. It is proposed to endeavour to reach an understanding with France and Germany with regard to the wave length, in order to bring the whole system into agreement. Telefunken stations are to be established at Tabora and Udjidji, in German East Africa, and French stations are to be erected at Loango and Brazzaville. It will therefore be possible to telegraph through the whole of the African Continent from the port of Dar-es-Salam and thus obtain a connection with Europe through a cable on the West Coast.

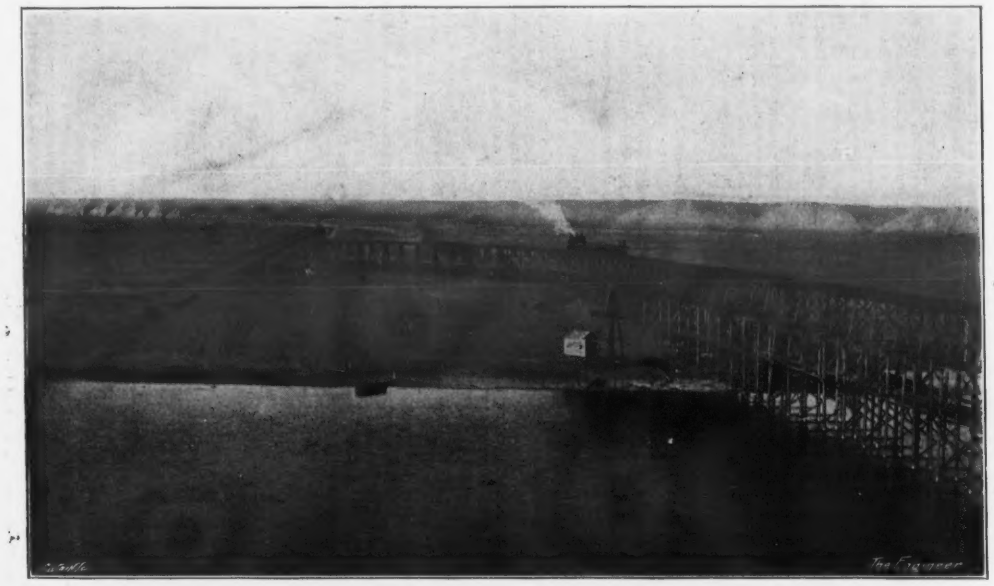
THE designs of the United States destroyers, eight of which vessels were authorised at the last session of Congress, to have the highest practical speed, and the cost not more than £165,000 each, provide for a larger boat than the destroyers of 1910 design. The latter vessels possess a displacement of 750 tons. The destroyers next to be contracted for, according to the *Army and Navy Register*, will have a displacement of 1000 tons. This increase in size will be utilised almost entirely in providing additional space for liquid fuel, it having been determined that in that direction the most profitable change may be made. The speed of the destroyers will not be increased. By the additional 250 tons displacement there will be gained an endurance of 2000 miles. The 750 ton destroyer has a radius of action of 4000 miles at 10 knots; the larger destroyer will be capable of 4000 miles at 15 knots, or nearly 6000 miles at 10 knots. The 1000-ton destroyers will be of the oil-burning variety, as are those of the preceding design.

IT is reported in the *Electrician* that work has just been commenced by the Shawinigan Water and Power Company on the construction of an electrical transmission line from Shawinigan Falls to Montreal, a distance of about 85 miles. This line will consist of two three-phase circuits. A new receiving and distributing station is now being erected by the company near its other east end station at Maisonneuve. This will be the Montreal terminal of the new line. The cable will be worked at 100,000 volts, and will be capable of carrying the equivalent of 25,000 horse-power. This load will constitute the first instalment of a contract made by the Shawinigan Company to furnish the Montreal Light, Heat, and Power Company with 60,000 horse-power. The new line between Shawinigan and Montreal will follow closely the route of the Canadian Pacific Railway between those points, and for the greater part of the distance will be about 10 miles from the line built a few years ago, which lies close to the Canadian Northern Railway. The construction work will be done entirely by the company's own staff. When this line is completed, the company will be ready to build another line to furnish the balance of the power required by the Montreal Light, Heat, and Power Company.

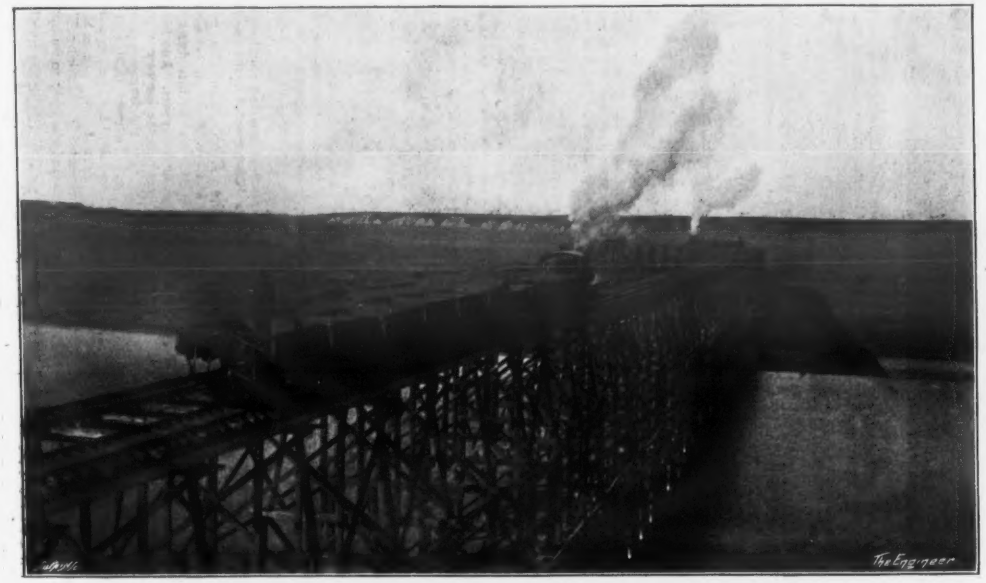
OVER forty years ago, after a serious epidemic in Starcross, those in authority established a supply of good water obtained from springs at the foot of Haldon. A reservoir was constructed, and water was brought to nearly every house. After a few years the supply became intermittent, and occasionally a quantity of green vegetable matter came through the water-pipes. An engineer discovered that the source of the supply was all right, but the method of its conveyance was faulty. The reservoir was abolished, and the water was collected by tapping the numerous small springs, and by pipes conveying these supplies into one large pipe, which led to a shallow well. From that well water sufficient to supply Starcross and a good part of the village of Cofton has been obtained. Unfortunately, Starcross has had more than its share of fires. The inhabitants, shortly after the new water arrangements, voluntarily supplied a manual fire engine too powerful for the water supply. To obviate the difficulty the authorities have now built and covered a reservoir not far from the well, but the supply is obtained as before. Larger pipes have been laid from the reservoir to Starcross, and recently the water has been conveyed through them. Starcross is now in hopes that fire and water scares will not be heard of again.

CONSTRUCTION OF THE HORSESHOE DAM ON THE BOW RIVER, ALASKA

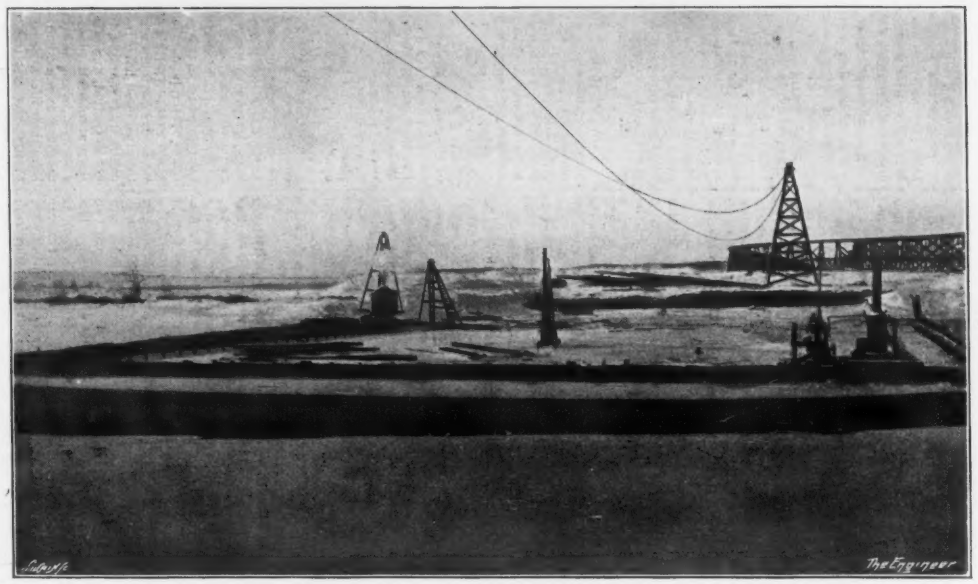
(For description see page 639)



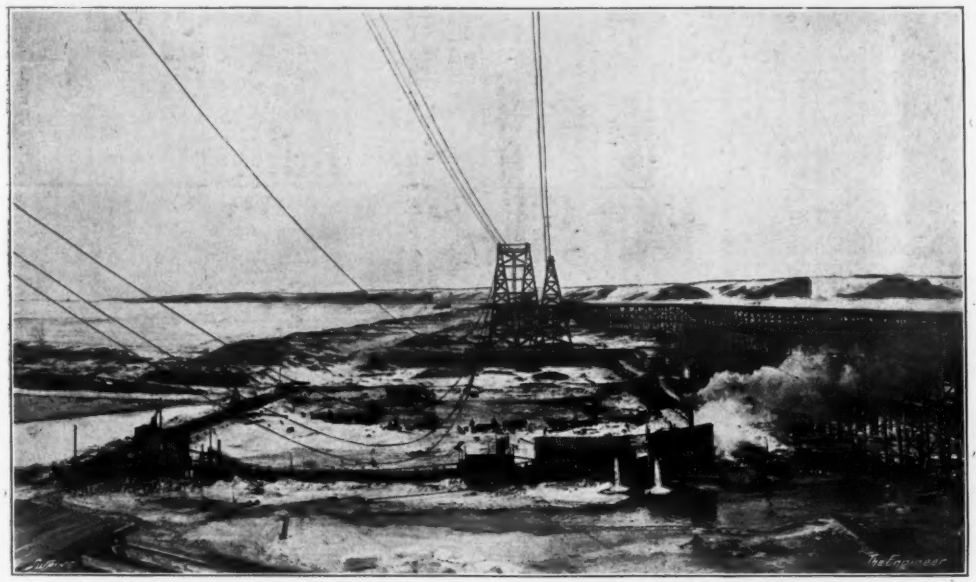
CONSTRUCTING THE EARTH DAM—NOVEMBER, 1910



CONSTRUCTIONAL TRAIN AND TRESTLE BRIDGE—NOVEMBER, 1910



GENERAL VIEW OF THE COFFERDAM—JANUARY, 1911



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*** *With this week's number is issued, as a Supplement, a Two-page Drawing of a Superheater Side Tank Passenger Engine, London and North-Western Railway. Every copy as issued by the Publisher includes a copy of this Supplement, and Subscribers are requested to notify the fact should they not receive it.*

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TWO-PAGE SUPPLEMENT—SUPERHEATER SIDE TANK PASSENGER ENGINE, LONDON AND NORTH-WESTERN RAILWAY.

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

MEETINGS NEXT WEEK.

(*See "Forthcoming Engagements" page* 654.)

THE ENGINEER.

JUNE 23, 1911.

The Parent's Point of View.

WE have already, in referring to the approaching conference on technical education, expressed a hope that some attempt would be made to obtain the views of parents upon any schemes that may be advanced. The programme has now been published, and we are disappointed to find that no special effort has been made with this object in view. Indeed, for the most part, the papers are to be presented by professors, which would be a matter for regret, were it not for the fact that the discussions will naturally prove of far greater interest and importance than the short addresses which open them. We say, without the least disrespect to the technical schoolmaster, that he is not the best judge of the training that should be given, because he is naturally only able to keep in touch with a few of his students after they have passed into the world of affairs, and then probably only with the best. However, that merely in passing; the object of the present article is to encourage some of the speakers at the conference to look at the question not only from the professor's point of view, the student's point of view, and the employer's point of view, but also from that of the parent.

It is probably impossible rigidly to standardise the education of engineers, but it is doubtful if we shall ever get a better scheme for general training than that recommended years ago by what was known as Sir William White's Committee, a committee formed of the most representative men of the Institution of Civil Engineers, which sat in 1905-6. The outstanding feature of that scheme was that the young engineer should go, on leaving school, straight to a works where he would spend at least one year. Thence he would pass to a technical college to take up his scientific education, and after he had won his diploma or taken his degree, would return to the works and complete his practical training. This plan was devised, as we have said, by a body of very capable men after very careful consideration, and none better has ever been proposed. Those who are attending the conference will do well to read the recommendations again; they will be found in our issue of April 27th, 1906. In spite, however, of the excellence of the scheme it has been very rarely followed. Indeed, we are not aware that any one save Mr. Donaldson at Woolwich has really endeavoured to adopt it, though several employers have agreed to it in a half-hearted way. But the stumbling-block in its path is the parent. He very naturally has a good deal of hesitation in sending a boy of sixteen or seventeen into the works. Frequently he fears for his son's health, but more often for his morals, and no one can doubt that in both respects his hesitation is justifiable. The boy of sixteen is frequently neither robust in body or mind, and both require the supervision of an elder. Few employers are prepared to accept the responsibility for an apprentice's health, and less still for his moral and intellectual welfare. Hence parents, as a rule, decide against the free life of a works, and send their sons direct to the technical college on leaving school. Some, a view in which they are supported by the professors, hold that a youth must lose touch with book work in his year of practical training, but with that aspect we do not propose now to deal. The Committee did not see any grave difficulty of the kind, and for the moment we propose only to consider if there is any means of meeting the very real objection which the parent feels to the Committee's scheme. Let us turn again to Mr. Donaldson's plan, as it affords us a practical example of how it can be done. At Woolwich the boys are taken from some recognised school after careful consideration of each case. On admission they pay no premium, but they deposit one hundred pounds as a guarantee of good conduct. As soon as they come under Mr. Donaldson's charge they must live in approved lodging, the owner of which returns periodical reports of the manner of life of his lodgers. After a year in the works the youth leaves for his college training, preferably at a university—Mr. Donaldson has a predilection for Cambridge—and when he has taken a degree he returns to Woolwich for several years. We are told that the plan is working well. The point on which we wish to lay stress is the method adopted for keeping an eye on the apprentices after shop hours. Mr. Donaldson's plan of certified lodgings has much to commend it, and it has, moreover, the advantage that it lends itself to extension. For example, we suggest that it would be quite possible for a science master to establish a house, like the houses in public schools, where he would not only lodge a number of apprentices, but would assist them with their studies in the evenings. The parent then would have no hesitation in sending his son to works at the age required by the committee's scheme. In the works a youth is likely to acquire no worse vice than the command of a somewhat flowery language, with a strange reiteration of a few irrelevant adjectives. It is not in the day-time that moral and intellectual damage is done. It is the evening and the dread of solitude that leads to dangerous companionships, and it is then that the influence of the head of the "house" would come in. We are far from desiring to see any mothering of the 'prentices; the sooner the young engineer breaks away from the apron strings the sooner he will be able to take a useful place in a life which is often rough and thorny, and which demands more than most professions the self-reliance of its followers; but a wise house-master would know exactly how far to go, and in the course of time would gain a reputation for turning out the best men. Another plan would be for the works themselves to own hostels, where the youths would be lodged and fed at certain recognised rates, and which would be under the charge of capable superintendents. This is not a great step in advance of what is already done in one or two works in the case of working-class apprentices. In one instance we know of an ex-sergeant in the army is held responsible for the behaviour of a number of boys on whom he keeps a watchful eye, not only in the works, but outside.

If it should prove possible for some such schemes as those we have outlined to be generally adopted, we believe it would be found that the parents' objection to sending boys to works direct from school would soon disappear, and the road would be paved for the best scheme of engineering education with which we are acquainted. It is, let us say once more, very sincerely to be hoped that the parents' view of the case will not be lost sight of at the coming conference. The best plan that professors and employers can devise will be sterile if they do not recognise that fathers and mothers have also opinions that must be bargained with.

The Suspension of Motor Vehicles.

BETWEEN the surface of the road and the load are interposed certain mechanical devices which constitute what we have termed the "suspension" of motor vehicles. The load may be humanity or beer. Its carriage is the ultimate object to fulfil which the entire vehicle has been constructed. It is desirable in all cases, essential in many, that the load shall be shaken as little as may be. The amount of unmodified shaking depends very much on the road and the speed. The first attempts to reduce it seem to have consisted in suspending the body of the vehicle on the under carriage or chassis by means of leather straps. Subsequently leaf springs, standing nearly vertical, were secured to the axles, and to the upper ends of these the leather straps were buckled. This arrangement permitted lateral swing, and constituted an enormous improvement. Then the springs were bent, and the C spring suspension came into fashion, and is still popular after about two centuries of life. More recently a further advance took place. A species of secondary chassis was interposed between the axles and the C springs, double elliptical springs being introduced. The result was what the French called "La voiture á huit resorts"—the eight-spring carriage which represented the last word in opulent luxury. We write of these things because the principles involved in the suspension of vehicles are immortal; and we find in the past lessons which may be studied with

advantage in the present day. Roads and road surfaces are, in this country at all events, better than they ever were before, and the amelioration of our highways continues. To a certain extent, however, the increase in speed has neutralised the betterment of roads, and spring suspension, or its equivalent, is at least as necessary as it ever was.

For the moment we may leave out lateral displacement, and consider only the vertical disturbances of the vehicle—so far, at least, as the larger movements are concerned. When passengers are carried we must study vibration as well, and the means used for dealing with vertical displacements will not as a rule have any effect on the vibration of which we are writing. We may have a vehicle atrociously uncomfortable as regards the one, while it is quite satisfactory as regards the others. It is advisable to keep this fact steadily in mind. In the modern motor vehicle vibration is stifled by the use of india-rubber and compressed air, while the large vertical displacements are still dealt with by means of steel springs. The springs would be useless were it not for the inertia of the load. Instead of the load being lifted and allowed to fall as the wheels climb the inequalities of the track, and descend them again with more or less suddenness, it is supposed to keep steadily on, the spring bending and straightening. It is matter of common knowledge, however, that the spring cannot adjust movements with this precision. Very pretty mathematical problems may be constructed concerning the inter-action of the road, the load, inertia, *vis viva*, and momentum. The weight of the spring itself plays an important part. Then we have the recoil action to consider. This last affects the problem very materially. It goes without saying that the longer and more elastic the suspension springs are the easier will be the motion, but the greater is its range; and to get what may be termed "dead beat," "cataracts" and braking devices are being used. Large numbers of patents have been taken out, especially in the United States, for what are variously termed "shock absorbers," "range reducers," "vibration arresters," and so on. Lastly, we have the pneumatic tire, which, it is not too much to say, made speed possible on the highway, and so gave birth to the motor car. Of late, however, the question is being asked—Is the pneumatic tire a necessity? and there is a growing belief that, save for vehicles of maximum luxury, it may be found that it is not. The improvement which has been brought about in roads by the introduction of the motor car is beginning to react on the car; and it is really not too much to say that on many great highways it is now possible to run at speeds up to 25 miles an hour on solid tires with as much comfort as could be had with pneumatics on the same roads ten years ago.

The pneumatic tire has given an ease of motion which may be regarded as unparalleled. A high-powered modern motor car runs with greater smoothness at speeds up to 40 miles an hour than the best first-class railway carriage in the kingdom. But this end is attained at an enormous price. It is not the luck of the majority to be able to pay £60 or £70 for a set of tires whose life after all is limited to six or seven thousand miles. Furthermore, it appears that about 10 cwt. is the maximum load that a pneumatic tire will carry. Omnibuses, *char-à-banc*, and vehicles of the kind, must use solid tires, and in these cars very great improvements have been effected, and more are imminent. But there is good reason to think that the use of the solid tire may be found possible with much smaller cars. Given good roads, it seems to be a question of springing, and the provision of general restrained elasticity. While the chassis has interposed between it and the axles one set of springs, there is nothing to prevent the following of the example set by the old coach builders and the interposition between the carriage body and the chassis of a secondary set of springs. In railway practice the double springing has long been in favour. Between the sole frames and the coach body blocks of india-rubber are interposed, which take up that disagreeable vibration to which we have referred. It is well known that, even as regards locomotives, the interposition of india-rubber "cheeses" between the spring hangers and the frames promotes the longevity of the springs and makes the engine "ride easier." In the little steam cars which came to this country from the States ten years ago, the introduction of flexibility of frame was most carefully studied, with the utmost benefit as regarded the avoidance of twisting stresses. There is a well-known cheap American car in the English market which may be regarded as a model of spring suspension. In all that concerns suspension the pneumatic tire has hitherto been regarded as covering a multitude of sins. But the tremendous price which rubber has attained, and the improvement effected in the roads, is causing the whole position to be re-considered. In the heavier vehicles the cutting off of the vibration set up by the engines from the car body is being studied. Gear-boxes are being made silent, better designed road wheels are being used, and in all cases these attempts to attain to better results than any had before are meeting with success. What can be done with our four-ton omnibuses ought to be possible with much lighter carriages.

Apart from the cost of the pneumatic tire, we have its liability to puncture at the most inconvenient times and places. The solid tire gives complete exemption from this. That the solid tire will ever be found suitable for very costly cars and high speeds we do not believe; but there are thousands of smaller cars to which it ought to be applicable. It is in the main entirely a question of resilience. No doubt modifications in the design of cars will be found necessary. At present there is incredulity on the part of the builders of cars and the public; but let it once be realised that the conditions are no longer what they were ten or even five years ago, either as concerns the surfaces of our roads or the construction of chassis, and the solid rubber tire will assume a different position, and this we say as result of recent personal experience, and that on roads by no means the best in England, at speeds up to 25 miles an hour. The cost of a solid tire is, say, three times that of a pneumatic, but it will last six times as long, and is worth something when worn out, while the pneumatic is worth little or nothing. But a special wheel is wanted for the solid tire, and that has yet to be invented. It will beyond doubt come with the demand for it.

Railway Accident Returns.

IN the debate on the Vote on Account on the 15th inst., one of the railway servants' representatives drew attention to the fact that during the year 1910 there were 25,137 men injured on the railways of the United Kingdom, whereas in 1901 the number of non-fatal accidents was only 14,740. To this the President of the Board of Trade replied that the figures were not strictly comparable, because the basis on which these returns are made has been altered of late, and a larger number of smaller accidents is brought in now than before; and though he did not deny that there had been an increase, he did not think that the proportional increase was quite so great as was represented. Mr. Buxton then proceeded to say that it was a subject that the Board of Trade was carefully watching, and he was "sure that such representations as we make and such improvements as we suggest to the great railway companies will be adequately and sympathetically considered." Before going further, two things should be noted. One is that the men's representatives admit that there is a satisfactory decrease in the number of fatal accidents. The other point is that the 25,137 non-fatal cases are made up of 113 injured in train accidents, 4605 injured in shunting, marshalling, or by other movements of trains or vehicles, and 20,419 injured in goods sheds, engine sheds, on stations, or on the line in other ways than in train accidents or by the movement of vehicles. If, now, our review of the Railway Accidents Returns for 1910—THE ENGINEER, May 26th—be referred to, it will be seen that there is no ground for complaint as to the numbers under the first two of these heads. The last item of 20,419 injured is hard to justify; yet we are satisfied that in this, too, there is no need for uneasiness. Part of the increase is due to the amended returns that came into force on January 1st, 1907, and to which we referred in our previous notice. The number of fatal cases under this heading has actually decreased, and we are therefore compelled to come to the conclusion that the increase is solely due to greater care on the part of the companies in reporting minor accidents—a conclusion that is supported by a study of the table as to the nature of the injuries and the occupations of the disabled servants.

This reference to reporting accidents will suitably lead up to another interesting observation. In the same discussion, attention was drawn to the number of failures of couplings, and it was pointed out that of 2174 such accidents 620 occurred on one line; that out of 239 broken rails no less than 66 were reported by that same company, which, we may also add, reported 46 failures of springs, &c., out of 82, and 25 failures of axles out of 77. But there need be no cause of uneasiness in this. The company concerned is one of the leading English railways, and certainly no company's rolling-stock is better constructed or maintained. The explanation the apparent high percentage is that the company has adopted a liberal standard as to what accidents to report. Another company shows up badly in the matter of the 20,419 injured in goods sheds, &c. It reported 4122 cases, while other companies of practically equal traffic movements, whose practice in this matter is not so general, reported only half as many. The Great Eastern had apparently more than the North-Eastern, which is absurd, and while the North British had 156 men injured by the movement of vehicles as against 125 for the Caledonian, which is about a right percentage, the latter company reported 355 cases of injury in goods sheds, &c., but the North British sent in only 175. Again, the order of December 21st, 1906, calls, *inter alia*, for reports of "all cases of goods or mineral trains or engines leaving the rails on running lines." This may be read to apply to engines leaving the rails at points—an almost every-day occurrence—yet some busy companies only reported one or two in the whole year.

In November, 1905, the Board of Trade issued a circular to the railway companies in the hope of securing more accurate returns, and this led to the amended order of December, 1906. It is, however, apparent that uniformity is far from being attained, and something more should be done. It is probable that this might lead to an increase in the number of accidents being reported, but that is a minor matter so long as the mishaps themselves do not increase. As these returns are the only means of accurately gauging how safe British railways are, and since they can, from their remarkable record, afford to act generously in this matter, the companies might of their own free will take action in the matter. Possibly, too, it would pay, as were the officers responsible to know that true returns were presented, they would see that their standing was a high one.

ARTILLERY SCIENCE.

By SIR GEORGE GREENHILL, F.R.S.

THE Progress of Artillery, Napoleon said, is the Progress of Civilisation; meaning that the country which neglects the science is self-doomed to destruction. We welcome the appearance of Colonel Bethell's "Modern Guns and Gunnery" (Cattermole, Woolwich) as showing that a start has been made in this country at last to stimulate an interest so manifest elsewhere abroad, lacking which Napoleon would not give us a first class in civilisation. Recent history ought to have given a severe shaking to our self-sufficiency, in showing us that the rest of the world can show quite as much, to say the least, as anything we can accomplish.

Every civilian tax-payer is now a military critic, and he will never recover from the fright and despair of the last century, when our military decadence was dragged to the light, until he sees some realisation of the smooth words of official optimism. His historical attention is directed now to the downfall of countries due to their decrepitude through luxury and easy prosperity, and to the small difference needed to turn the scale of victory and defeat. The taxpayer was prepared to make unlimited sacrifice for the sake of peace of mind; but Financial Authority has stepped in to prevent him, telling us that the country was beaten to a standstill, and that no interruption could be made in the continuity of our policy of muddling through the next time.

We dare not think of the result of a continental struggle, threatening twelve years back, when our artillerist was unaware of the existence of the long recoil field gun, discussed here in Chapter VII., good enough to have knocked out our own puny effort. Then, as now, our regular was told he would never be required for war. No attempt has been made to rival the magnificent *champs de tir*, to be met in France every fifty miles or so by rail. And no horsey gunner of ours had the foresight to secure a ground open for steeple-chasing all the year through, obtainable as a gift from the State if used occasionally as an artillery practice range. The cost would have been a trifle as a set off against one of the hundred millions. It is too late now to secure such a site available for the Woolwich garrison, with Shooter's Hill as a butt for the stray shot. No range is nearer than the flat sands of Shoeburyness, useless for any instructional purpose.

Our regular gunner is not fond of a gun, and his peace drill and tradition tends to make him all groom and no gunner. He went into South Africa with a light heart; there he found his rivals all as good as himself, in the science of the horse as well as the gun. The regular is rather gun-shy, and prefers to gallop home to a quiet stable before the guns begin to shoot. The "terrier," we hope will be more keen, and jump for joy when he sees a gun taken down.

Colonel Bethell's book is written for Territorial interest, and should be much appreciated there; and Territorial enthusiasm must be the lever to force the hand of military authority, to make a start in modern efficiency. But the Territorial will have to give the lead by providing himself, at his own expense, with the artillery practice grounds now conspicuous by absence. Abroad the artillery arm receives the most careful attention; but a vicious system has

grown up with us by which our Artillery is depleted at the start of all first class talent, in practically the only avenue of entrance, the Royal Military Academy—to give it the full official title, never heard, but always replaced by a contemptuous significant nickname. The youthful genius, if an enthusiast of a purely military life in the artillery, is forced by a mercenary parent into a hateful service, like another Bride of Lammermoor, for the sake of an extra shilling of pay at the outset of his career; and the loss of such talent makes itself felt in the higher ranks of responsibility and initiative, where mobility is required of thought, instead of the intellectual timidity under which he is serving.

At the lower end of the Academy list there is no weeding out, and the pace is allowed to be set, as on the march, by the slowest. The liberal weeding in the Naval College under the new system is the most valuable asset of all the reforms, although obnoxious to the socialistic proclivity of a parent.

A spirit of emulation is to be encouraged for the health and prosperity of a country or institution. We have seen how New College, Oxford and King's at Cambridge have become valuable communities with the abolition of the old system of close election; and efficiency of the Royal Military Academy requires some similar reform if victory is to be organised there, and if it is to compete with the superior zeal we see abroad everywhere.

The present is a favourable opportunity for throwing the Academy into the melting pot, with its obsolete traditions, especially as competition for entrance has now come to an end. The effect, however, of absence of competition may not be harmful altogether if it implies a disappearance of mental indigestion and the jaded brain, product of a crammer. The raw material is as good as elsewhere, but it is not worked up to the best advantage for the service of the nation.

The Theoretical Gunnery at the outset of "Modern Guns and Gunnery" is based entirely on the method of Mr. Bashforth and his ballistic tables, derived from experiments made by him more than forty years ago. These tables have been replaced by new tables of character exactly similar, but much distended; based on experiment with modern guns, instead of the muzzle loading system available only in Bashforth's day. No effort was made, however, to follow the progress abroad since Bashforth's work, and so these new experiments do not have all the accuracy and value that could have been secured, and they show no improvement on Bashforth's method, although carried out by him in the infancy of electrical science with apparatus made by his own hand.

The supply of ammunition was stingy for these later experiments, but there was no stint of ink, and the ballistic tables run to seed, by contrast with the scientific condensation of the tables in Cranz's "Lehrbuch der Ballistik." An eye was kept on Krupp's results and Ingalls's tables, not trusting with insular timidity to our own work; and a fresh series of experiments and tables will soon be required.

The tables in imitation of Ingalls's have been made confidential, treating the laws of Nature as an official secret, and so no one will see them. A recent order makes all range tables secret and invisible, too, because of the columns of the 50 per cent. zone, pretending to represent the expenditure of much ammunition. So, too, in its care for our morals the public library blots out in the newspaper the columns of the betting. A wave of secretiveness is passing over our military offices in imitation of the French army before Sedan, but not discoverable in Berlin; and our military soul is driven in more than ever to feed on its own thoughts with unwholesome result.

Accuracy of Fire for the title of Chapter V. is misleading, as it would imply some incurable fault in the gunner, whereas it is the unavoidable defect of the gun and ammunition. The accuracy is determined in an ideal method regardless of expense by laying the gun in the same way as near as possible, without looking over the sights, and measuring then the divergence of the hits from their mean.

The theory is valuable in showing whether the gun is laid properly on the object by the percentage of hit and miss; also in estimating the number of rounds required for the destruction of the object, and whether it is worth powder and shot, and in discounting tall stories of wonderful shooting.

In some howitzer practice carried out once against a a cupola, "Here is your theory all wrong again," said the practical gunner, "the cupola has never been touched." "No," said Theory, "it is your gun is not laid properly; the point of mean impact is ever so far from the centre of the cupola."

Part II., III., IV. of "Modern Guns and Gunnery" is devoted to the detail and diagrams of the complete transformation of field artillery with the introduction of the quick-fire system, so called by us, and abbreviated to the initial Q.F., in accordance with our own inarticulate habit. But the Q.F. gun is merely B.L. (breech loading) with fixed ammunition like a rifle cartridge, and could not utilise its power until mounted on the quick aim (Q.A.) carriage; over which the gun is allowed a recoil long enough to keep the carriage from rearing up in the air and coming down crash on the wheels, upsetting the aim of the next shot, and causing the loss of time of a fresh laying.

The Q.A. carriage is designed to keep still on the ground, so as to be fired with effect as fast as the ammunition can be supplied, with the fuse set for the range.

The name "layer" still survives as a misnomer in the drill-book, and here on page 92, to show that the principle has not been grasped yet, that it is one gunner's business as the *pointeur* to keep the telescope sight on the target with a fine screw movement, and to fire as fast as the gun can be loaded, twenty times a minute, and to attend to nothing else. Other gunners attend to the elevation of the sight and setting of the fuse in accordance with the range-finder record, and supply the ammunition, all working calmly under cover of a steel shield. Such a contrast to our performance at the massacre of Colenso!

The dynamical principle involved is discussed here in Chapter VII., and was worked out in France long ago enough to have figured in the Dreyfus trial. But no Q.A. gun of ours went out to South Africa; we appeared there with a makeshift artillery outclassed at the outset. We were waiting to follow the lead of the rest of the world, so as to step in last of all and adopt their best, and then just as it was being discarded. The policy did not prove efficient, and cannot be called economical even, when we consider the hundreds of millions' bill. Colonel Bethell writes on page 383: "From time immemorial it has been the privilege of the regimental officer to grumble at the material supplied to him." But the taxpayer's complaint is that he did not make his grumble heard; on the contrary, he tried to curry favour by declaring everything was of the best, and that our feeble 15-pounder was the best gun in the world.

"Modern Guns and Gunnery" is suitable in scope for the junior and territorial officer, the master gunner, and sergeant-major; it is a creditable piece of work in print, diagrams, and binding, and in contrast to the shabby look of the official treatise. A comparison can be made with the recent "Lehrbuch der Ballistik (Teubner)," by Professor Cranz, an authority selected by the German Government for his knowledge of the subject, and provided with full scope and encouragement in his teaching at the Berlin Militärtechnischer Akademie. Here is a real efficient institution fully equipped, such as this country thinks itself too poor to afford; and in comparison with the German officer trained there, our military expert is the undisciplined volunteer, product of an inefficient economical system, with no fixed policy. But the German we know has a definite object in view.

But where is our military treatise to be found, the equivalent to Cranz's "Lehrbuch," and who is the officer in our service who would study it?

No regular would read an official treatise except on compulsion; his enthusiasm is extinguished at an early stage, and the nature and appearance of the book leave him unconcerned. But it is a serious matter to the Territorial that his zeal should be damped, and his respect diminished for authority.

There are well-founded complaints of the antiquated perfunctory nature of our official text books, prepared by anybody, pounced on regardless of fitness for the task, as by word of command from authority—"Let this book be put in hand at once, and at no expense," in the formula the Territorial knows so well.

LITERATURE.

Electric Motors: Their Action, Control, and Application. By Francis B. Crocker and Morton Arendt. London: Crosby Lockwood and Son.

THERE is a great deal in this book which may be studied with advantage by those who are desirous of understanding the action of electric motors and of acquiring information relating to their use. It is a book that has been written on practical lines, and should prove useful to all interested in the subject of electric driving, for it deals very thoroughly with all the electric motors commonly employed, and enters into many considerations which demand attention when dealing with electric power problems.

There are a good many diagrams of connections showing the methods of joining up the various classes of motors, and it is worthy of mention that the authors have made these very clear. It is satisfactory to find that the method of connecting up commutating poles is properly explained, for troubles frequently arise owing to mistakes having been made in these. The speed control of continuous-current electric motors has also received much attention, but here the authors devote more space than is necessary to systems of speed variation which are seldom used. We refer to Chapter VII., which is devoted to the speed control of motors by variation of field reluctance. Following this chapter there is one on the multiple voltage control of the motor's speed, wherein the Ward Leonard, Crocker-Wheeler, Bullock, and other systems are described, and here again we find some systems which have met with little prominence. The chapter on the control of direct-current series motors gives descriptions of various systems of speed control adopted on tramways and railways, and an instructive table is included showing a comparison of the different methods for starting series motors with uniform acceleration. A short chapter on compound motors clearly describes the behaviour of these machines, and enters into the question of connecting the series winding so as to assist or oppose the shunt coils. Here curves are given showing what happens when the excitations due to the two sets of windings are changed, and from an inspection of these the effects of weakening the shunt excitation and strengthening the series field at once become apparent

In entering upon the subject of alternating-current motors, the authors first of all give some historical information, and references are made to various patents granted to the early workers in this field. Much is said about the synchronous motor, and many interesting considerations are entered into concerning the operation of these machines. An ingenious means has been devised for explaining how a rotary field is produced in an induction motor. The various means of starting induction motors are briefly considered, and also the methods commonly adopted for varying their speeds. Some reference might have been made in this section of the book to the "Spinner" motor, and also to Mr. Hunt's cascade motor, for both of these machines are specially designed for speed variation. The methods of changing the speeds considered are by varying the frequency, by varying the number of poles, by varying the rotor resistance, by varying the applied voltage, and the cascade method. Much space is devoted to single-phase motors, and these are considered under two headings, *i.e.*, induction motors and commutator motors. In dealing with the former class of machine, the authors explain various phase splitting devices as used for starting single-phase induction motors. Repulsion motors are naturally dealt with in this section of the book, but the information given concerning these is very brief.

References, however, are made to other books and publications in which further information may be found. In fact, this practice of giving the titles and the names of the publishers of other books of a kindred nature has been adopted throughout the volume, and it appears that the authors have made reference to all books on electric motors of any importance. It is quite evident that a book of this description, treating as it does all kinds of electric motors, cannot deal with electric motor design, nor can the authors be expected to go very deeply into theoretical considerations. A complete treatise on the alternating commutator motor above forms a very fair sized volume, and it is therefore evident that little more than a general explanation of the theory of single-phase commutator motors can be expected in a book of the kind under review. The information given concerning these motors will appeal to practical men who are desirous of acquiring a little knowledge which will enable them to understand how the single-phase commutator operates. The same, in fact, applies to all other parts of the book, for it is essentially a practical man's volume, and deals with points connected with the operation of motors rather than design. A concluding chapter has reference to service conditions and applications of electric motors. Altogether the work constitutes a useful addition to this class of literature, and is worthy of a place on the practical engineer's bookshelf.

SHORT NOTICES.

Aerial Locomotion. By E. H. Harper and Allan Ferguson. Cambridge: The University Press. Price 1s. net.—Manuals on scientific or technical subjects written for the general reader have usually many shortcomings. To achieve understandability the authors of such works frequently "simplify" their language to such an extent as to become almost childish, or they will sacrifice that love for the whole truth which lies at the base of science. The present volume forms one of a new series being issued by the Cambridge University Press on literary and scientific subjects, but in spite of the fact that it is primarily a "popular" volume, it is by no means devoid of interest to the expert. It is almost entirely free from the defects to which we have referred above, and as an introduction to the whole field of aeronautics it should secure a wide popularity.

Electricity in Locomotion. By Adam Gowans Whyte. Cambridge: The University Press. Price 1s. net.—This is another of the series referred to above. In it the author attempts to give a picture of the part which electricity has taken and will continue to take in the development of locomotion. His subject is a vast one, but the author has tackled it with enthusiasm, and has produced an account of it quite in keeping with the aim and object of the series of which the volume forms part. The electric tramway and automobile, the trackless system, the electric railway, petrol-electric vehicles, and marine propulsion by electricity, are all dealt with in a lucid, accurate, and acceptable manner. There are many who, although not engineering experts, take a deep and intelligent interest in things technical. To such the ordinary popular book is almost as wearisome as it is to the professional man. In this volume, however, they will find real pleasure, and to them and to others beginning the serious study of the subject, it is to be highly recommended. We must not fail to notice the excellent manner in which these little volumes are bound and printed. The clear type, the paper, and the strong binding make them a pleasure to read and to keep.

Die graphische Statik der starren Systeme. Dr. Lebrecht Henneberg. Teubner, 1911.—The cat, dog, and other animal can still enjoy the intellectual pleasure of finding out things for himself; all except the human animal, who cannot find time to assimilate the extra knowledge now exacted, unless his mental pabulum is cut up for him very small on a plate, so that he take it down with a spoon. The present volume is the article from the "Encyclopædia of Mathematics," expanded to three or four times the original bulk. Graphic Statics is useful to the engineer who thinks and calculates on a drawing board the designs, say, of a Forth or Quebec bridge; and it provides some flavour of reality to Descriptive Geometry, a subject requiring very little thinking but making a brave show, and hence popular with the student, but absorbing much time, which, in the opinion of many professors, could be spent more profitably on hard drill in the Calculus. The example diagrams of the book are the chief feature, but the explanation should be left more to the ingenuity of the student to invent for himself; not to take down from the lecture of a professor. The German student has no time to think.

Economy in Sewage Disposal, together with a History and Description of the Sutton, Surrey, Sewage Works. By C. Chambers Smith. London: The Sanitary Publishing Company, 5, Fetter-lane, E.C. Price 1s. net.—This claims to be a practical guide for councillors, surveyors, and works managers. The first portion of the book is devoted to a series of paragraphs containing general advice as to procedure which in large measure advocate greater economy in the design and management of sewage disposal works. Several assertions are made, which will not be universally accepted, but, on the whole, the remarks, though they are hardly given in sufficient detail, will be found useful. The second part of the book deals with the disposal works at Sutton, Surrey, and gives a history and a fairly complete description of them.

BOOKS RECEIVED.

British and Foreign Building Stones. By John Watson. Cambridge: At the University Press. Price 3s. net.

The Calculation of Columns. By Theodor Nielsen. London: E. and F. N. Spon, Limited, 57, Haymarket, S.W. Price 4s. 6d. net.

Surveying Sheet for Professional and Educational Use. London: Crosby Lockwood and Son, 7, Stationers' Hall-court, E.C. Price 1s. 6d. net.

NEW ROLLING STOCK, SWEDISH STATE RAILWAYS.

IN the illustrated articles published in THE ENGINEER of July 16th and 30th, 1909, detailed information was given relative to the new German-Swedish railway train ferry service between Sassnitz and Trelleborg, and also of the steamship Drottning Victoria, which was built by Swan, Hunter and Wigham Richardson, Limited, of Walker-on-Tyne, for carrying the railway trains between these two ports. In the present article we are enabled, by the courtesy of Mr. T. W. H. Pegelow, of Stockholm, the Director-General of the Swedish State Railways, to illustrate and describe three of the types of new passenger rolling stock which have been specially built in connection with this railway train ferry system. Comprised in this new passenger rolling stock are eighteen sleeping saloons, nine combined first and second-class cars, nine combined third-class and luggage cars, and nine postal vans. Of these, the Prussian State Railways Administration have furnished the nine combined first and second-class cars, three combined third-class and luggage cars, and three postal vans, whilst the rest of the equipment has been built on behalf of the Swedish State Railways by private rolling stock manufacturers in Sweden. The three types of coach—sleeping car, combined third-class and luggage car, and the postal van—are shown in Figs. 1, 2 and 3 respectively.

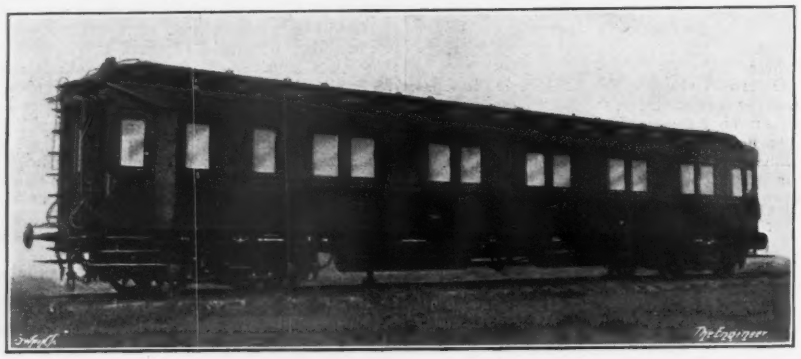


Fig. 1—SLEEPING CAR

The underframes are in all cases constructed of channel beams, connected by knees and gusset plates, and strengthened by queen post trusses. The cars are provided with continuous drawgear. The buffers at each end of the car are connected by a link motion, designed with the object of allowing the buffer springs to absorb the shocks and promote a smooth running round curves. The underframes are mounted upon four-wheeled bogies with pressed steel frames, according to the standard practice of the State Railways. The details of these bogies are shown in Fig. 4. The car bodies are constructed of oak or ash posts and beams connected by tenon joints, which latter are strengthened with iron angles and stays. The floor and side panels are made of Swedish pine, strengthened with iron bracing, and the outsides are covered with sheet iron. The floors are made of two layers of wood, the space between being filled with cork dust. Particular care has been paid to make the riding as quiet as possible, and between the body and steel underframe blocks of "Trichopiece" are inserted at those places where the car body is bolted to the frame.

For securing the cars to the ferry, the lantern sides and the side beams in the underframe are provided with forged loops, placed at points corresponding with similar loops on the ferry, these loops being connected by screw couplings. The Prussian State Railways' standard vestibule diaphragms are adopted, and the cars are equipped with the Pintsch system of incandescent gaslight. The amount of gas stored in each of the sleeping saloons and combined third-class and luggage cars is 1600 litres, and in the mail cars 2760 litres. As the Swedish State Railways are using the vacuum air brake, and the Prussian State Railways the compressed air brake, these cars are equipped with both systems. The improved type of triple valve is introduced on the Westinghouse system. For emergency purposes, handles operating either system of brake are provided in the compartment and corridor, and hand brakes are arranged at both ends of the cars. All the vehicles are constructed according to the specifications of the Prussian State Railways, and they are therefore also equipped with fire extinguishers, axe, and saw.

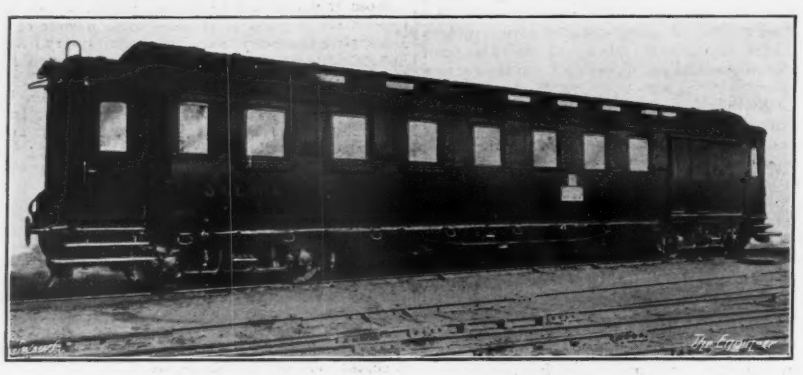


Fig 2—COMBINED THIRD-CLASS AND LUGGAGE CAR

The cars are heated by steam at four atmospheres pressure, taken from the locomotive. From the main pipe the steam is carried through pipes to radiators in insulated boxes arranged in or below the floor. Fresh air is taken from outside the cars through holes in the bottoms of these boxes, and after passing the radiators it flows into the car through an opening at the top, which is provided with a lid to regulate the temperature. To obtain circulation of the steam and to carry away the air in the radiators at the beginning of the heating a small pipe is inserted in each radiator, with a small hole at the upper end near the top of the radiator, these pipes being connected to a second main pipe opening into the outside atmosphere at the ends of the car. In addition to the steam heating, the mail cars are furnished with a coal-burning stove.

The cars are also equipped with water tanks of tinned copper, placed in the roof, from which the water is carried in a pipe system to the wash basins in the lavatories, and for the sleepers as well to the cabinet lavatories in the sleeping compartment, and to the wash tub in the attendant's room. The tanks are filled through a pipe system and a hose connection on each side of the car. At places where full water pressure is not obtainable the tanks are filled by means of a pump, which is mounted inside the car. To prevent a decrease of temperature of the water in winter time a coil of ¾in. steam pipe is fitted in the tanks and supplied from the heating system.

The sleeping saloon is divided into ten sleeping compartments, one attendant's room, two lavatories, and at each end a vestibule entrance. A corridor connects the two vestibules. The sliding door leading to the corridor is provided with a window to let in sufficient daylight. Each compartment contains an upholstered seat convertible into berths, and then providing sleeping accommodation for two persons. The upper berth consists of the back piece of the sofa drawn horizontally out from the wall and supported by brass hinges. The seat, or lower berth, is made into a box, in which the mattresses and blankets are kept. In each compartment is a niche for water-bottle and glasses cased in the partition separating two compartments, and below this a cabinet lavatory furnished in mahogany and provided with usual fittings, and a folding wash-basin of nickel plate. The interior furnishing also comprises a folding desk covered with linoleum below the window, a bevelled mirror in mahogany framing, and a ladder to be used when entering the upper berth. In the sliding door is sunk a thermometer, which can be consulted as easily from the inside of the compartment as from the corridor. Hat and coat hooks and basket racks are also fitted on the walls. The lavatories are provided with wash-basin of nickel plate and closet hopper fitted with mahogany double covers, usual lavatory fittings being provided. In addition, there is a mahogany cabinet for towel and a basket for used towels of mahogany laths kept together by nickel-plated brass strips, a soapholder, a bevelled mirror in mahogany frame, a holder for water bottle and glasses, &c. A swinging door in the middle of the corridor divides the latter into a smoking and non-smoking compartment. Eight folding seats are placed along the side wall and above the windows are four basket racks for luggage. Besides there is a number of hat and coat hooks fixed in suitable places. On the sliding doors leading to the sleeping compartments are number plates with adjustable figures, showing occupied and vacant seats. Closets for cleaning equipment are built in the vestibules beside the lavatories. All the window sashes and frames in the cars are pure mahogany, and the windows are made of double glass. The drop windows are supported by Laycock's patented window counterbalances, the blinds being also of the Laycock pattern. The cars are equipped with electric bells, two bell pushes being placed in each sleeping compartment, one bell in the attendant's room and a semaphore outside of each compartment showing where the signal was given. The wiring is arranged to connect with the dining car by means of cables coupled between the cars.

The principal dimensions of the cars are:—

	Sleeping saloon.	Combined 3rd class and luggage car.	Mail car.
Length over buffers, feet	77.6	64.9	60.0
,, ,, body ,, ...	63.7	60.6	55.8
Width of body, feet	9.5	9.7	9.7
Number of seats	20	32	—
Weight in running order, tons ..	41.1	37.2	35.3

The combined third-class and luggage cars consist of four third-class compartments, a vestibule entrance, with a lavatory and a corridor at one end of the car with luggage and guard's compartments at the other end. The seats in the third-class compartments are made of varnished wooden strips in alternating white pine and teak. Below the windows in each compartment is a folding table with a linoleum covered plate, and parcels racks, made in a way similar to the seats, are arranged on the walls. The sliding doors are provided with windows. The walls in the lavatory are covered with enamelled zinc sheeting to a height of 1.5 m.—nearly 5ft.—and above this the wall is painted mahogany colour as well as the door. In the lavatory is a closet with hopper of porcelain, fitted with double covers of varnished teak and a wash-basin of nickel plate. Besides, there is a holder for water bottle and glasses, a mirror in teak framing, towel holder, &c. On the side wall are placed three basket racks for luggage, a holder for water bottle and glasses, a mirror in teak framing, and hat and coat hooks. On the floor is placed a grating, composed of varnished oak laths, on a bed of zinc sheetings.

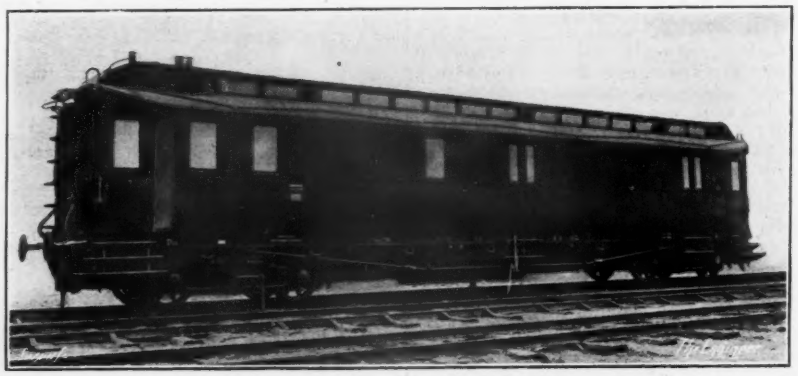


Fig. 3—MAIL CAR

The luggage compartments, an interior view of one of which is given in Fig. 5, have sliding doors on both sides, and the outside of these is covered with sheet iron. The compartment is divided into two parts by a low counter lined with sheet iron. This counter is intended to be used for customs duty. At one end of the counter a 50 kilos. pointer scale weigher is placed, and on a shelf a small weighing machine for parcels. There are also a dog cage, holders for spare hose couplings for brakes and heating systems, and brackets for signal lanterns, &c. The compartment is also provided with a tool-box, surgical case and medical equipment, and a box for signal equipment.

The guard's compartment is provided with a cab in the roof, built by an extension of the lantern sideways. At one of the side walls a platform is erected for a fixed leather cushioned seat and a table. Below the platform a couple of cupboards are arranged. Besides, there is a writing desk with leather cushioned chair, two shelves, two basket racks, and two folding seats. The compartment is equipped with gauges for air and vacuum brakes, as well as for the steam heating system. The window sashes and frames in these cars are varnished teak; the drop windows are, like those in the sleeping cars, supported by Laycock's patented window counterbalances, and the blinds are also of the Laycock system. The windows in the lantern, as well as the windows in the sliding doors, are provided with curtains. These cars are equipped with an electric bell system arranged similarly to that in the sleeping cars, except that connection is only made with the dining car.

The postal sorting cars are divided into an office section, a packing section, and two buffer compartments, one at each end of the car. In the larger of these is arranged a toilet and wardrobe, and in the smaller one two cupboards. In the postal compartment a desk is placed along the walls. To the edge of this desk a ledge of ash wood is fitted; the desk

itself is covered with green linoleum, except that part which is used for sealing parcels, &c. This is covered with zinc plate. At the side doors in the middle of the car the desk has flaps. On the side walls and the cross wall in the office are arranged partitions, of which the highest are fitted with glass bottoms, so that the sorters may perceive if they are empty or not. The partitions placed before the door at the end of the office are fastened to the wall by hinges, so that they may be swung into the postal compartment when the door is to be used.

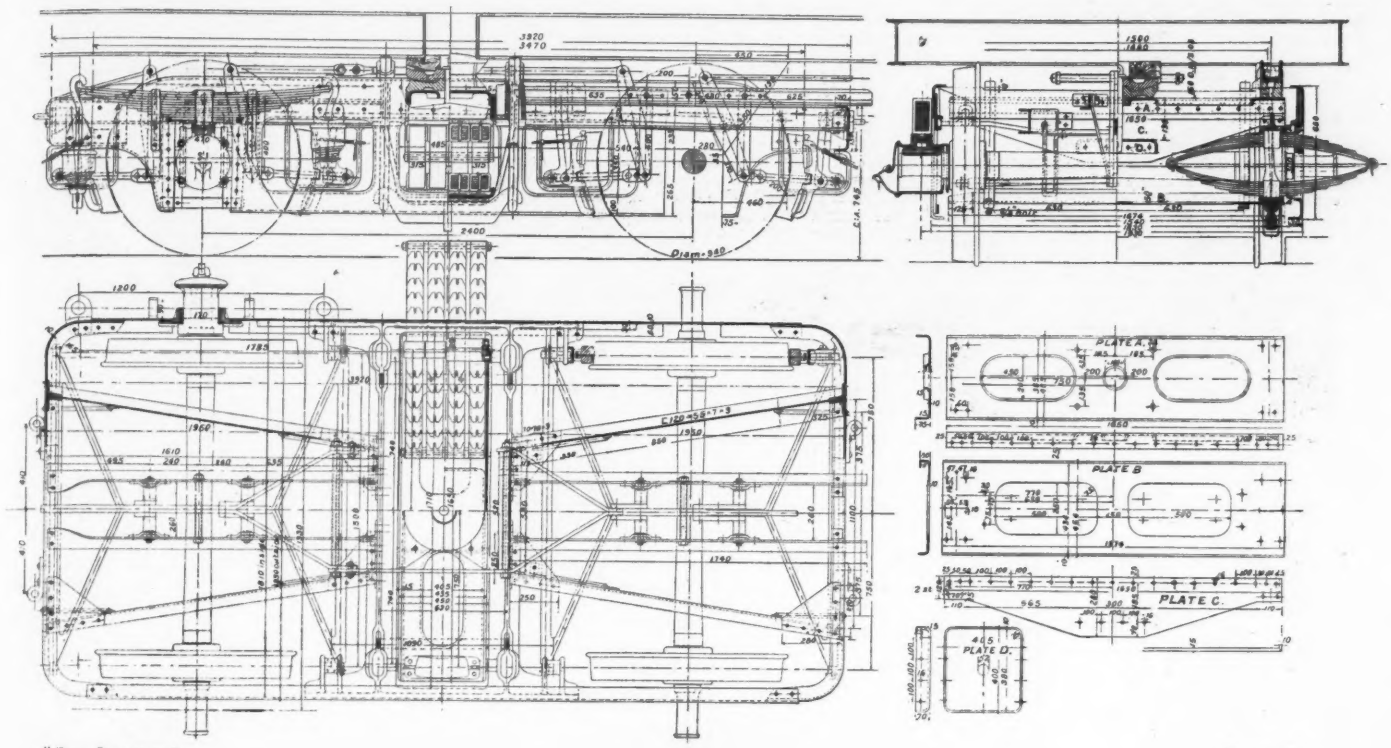


Fig. 4—COACH BOGIE, SWEDISH STATE RAILWAYS

Above some of the partitions on the side walls cupboards with sliding doors are arranged. For keeping postal matter of value and money there are partitions that may be closed by a balanced rolling front and a special cupboard. At each side of the car is one letter-box, accessible from the outside, for putting in letters. For hanging up mail bags, two frames of iron rods are placed at one of the walls with clamps on the rods for holding the bags. For mail bags and parcels two boxes of iron plate are arranged beneath the floor, accessible from the car through hatches. At the lower part of the lantern are fastened rods of iron covered with brass, on which

Fig. 5—INTERIOR OF LUGGAGE COMPARTMENT

parcels may be placed. Cupboards, drawers, shelves, waste baskets, stand for drinking-water, and six chairs with leather covered stuffed seats, complete the equipment of the post compartment.

LIFE-SAVING APPARATUS FOR USE IN NOXIOUS ATMOSPHERES.

IN the year 1907 the Council of the Society of Arts decided to offer under the Fothergill Trust a gold medal or a prize of £20 for the best portable apparatus or appliance for enabling men to undertake rescue work in mines or other places where the air is noxious, the object being to encourage the production of a rescue apparatus which would enable a succouring party to reach men cut off or overcome—in case of mining accidents—by irrespirable gases.

A number of appliances were submitted in March, 1908, and a committee was appointed to deal with them. It was, however, found impossible at the time to arrange for testing them, and the trials had to be postponed. At the end of 1909 it was found that facilities for making the tests would shortly be available, but so long a time had elapsed since the original offer that some inventors who had notified their intention of competing had already made considerable alterations and improvements in their apparatus, while applications had also been received from other inventors. The Council therefore decided to cancel the original offer and to accept for competition any apparatus which might be submitted not later than March 31st, 1910.

By the appointed date the following apparatuses were submitted:—

(1) The "Draeger" compressed-oxygen apparatus, by Richard Jacobson, 70, Shoe-lane, E.C., British agent of the Draegerwerk (Heinr. and Bernh. Draeger), Lübeck.

(2) The "Aerolith" liquid-air apparatus, by Henry Simonis and Co., Pretoria Works, Walthamstow, E.

(3) The "Meco" compressed-oxygen apparatus, by the Mining Engineering Company, Limited, Foster's-buildings, High-street, Sheffield.

(4) The "Weg" compressed-oxygen apparatus, with automatic supply, by W. E. Garforth, M. Inst. C.E., Snydale Hall, Pontefract.

(5) Siebe, Gorman and Co 's "Fleuss" compressed-oxygen apparatus (embodying improvements by Mr. H. A. Fleuss, Dr. Leonard Hill, F.R.S., and Mr. R. H. Davis), by Siebe, Gorman and Co., Limited, 187, Westminster Bridge-road, S.E.

(6) Apparatus for submarine work, using oxygen generated from a material termed "Oxylith," by Captain S. S. Hall, R.N., H.M.S. Mercury.

In addition to these there were two apparatuses which were sent in late, and certain less important devices, which were eliminated by the committee after a preliminary examination.

It will be noted that of the above apparatus four depend on the supply of compressed oxygen, one on the provision of air evaporated from liquid air, and one—that of Captain Hall and Staff-Surgeon Rees, sent in by the first-named—on the production of oxygen from "Oxylith." The committee reported with regard to the last-named apparatus, that there seems no doubt that though it is extremely well adapted for the purpose for which it was constructed—for use in submarines—it is not at present adequate for use in mines, except, perhaps, for short and easy pieces of work, where its lightness and simplicity might be advantageous. With regard to the apparatus of the other five competitors, the committee is satisfied that any one of them might be of the utmost value for use in mine accidents where access to the workings was prevented by their being filled with irrespirable gases. They would be valuable alike for the rescue of human life, and also for carrying on such operations as might be required; for instance, the construction of a wall to cut off part of a mine which was on fire, or the closing of a door to alter the direction of the air current.

The five apparatuses considered all vary in construction; each of them, according to the report, possesses details in which it is superior to the rest. The principal points of difference, apart from the fundamental principles on which the various apparatuses are constructed, appear in the comparative lightness and convenience of carriage, and in the arrangements for enabling the wearer to breathe either by the use of a helmet or by means of mouthpieces of various construction.

Fig. 6—INTERIOR OF MAIL CAR

The committee does not consider that the liquid-air apparatus sent in is as yet sufficiently perfect to justify its adoption in preference to the older systems, under which oxygen is supplied from a receptacle containing the gas in a state of compression. Liquid air, although, perhaps, it can in the future be obtained in sufficient quantities, and with sufficient readiness, is not easy to store; and it is probably hardly possible to avoid very great waste. Other points are the extreme cold produced by its evaporation, and the difficulty of properly regulating this evaporation. But the apparatus is one of the highest interest, and it is to be hoped that its development will be continued.

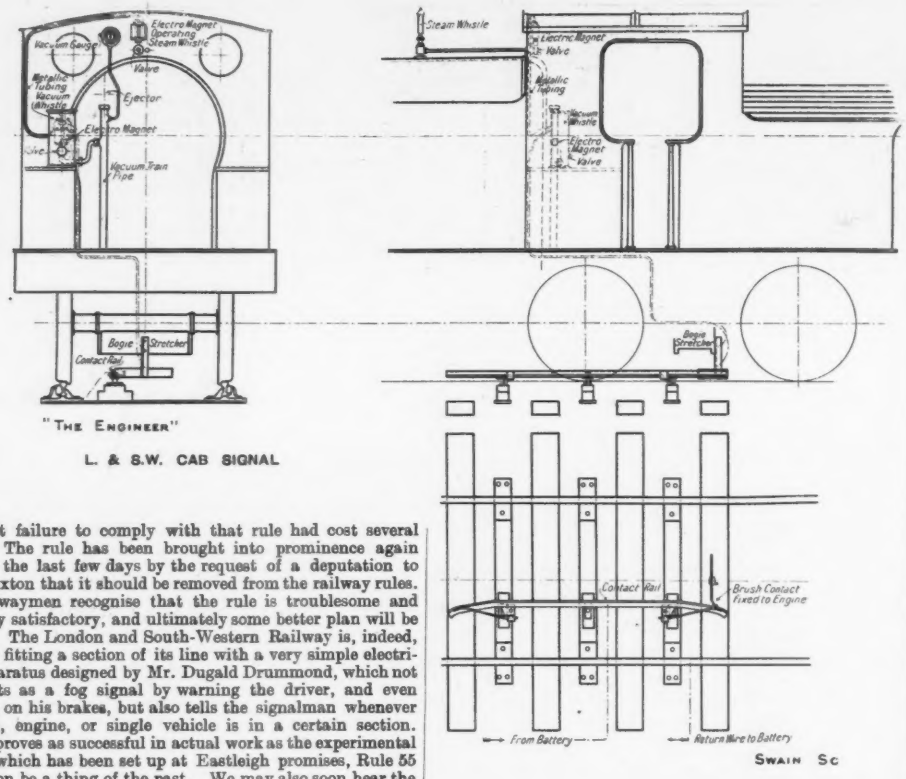
The committee has found a difficulty in reaching the conclusion that any of the other four apparatus is so far superior to the rest as to justify the award of the prize to it, and it alone. It is, however, of opinion that the apparatus originally invented by Mr. Henry A. Fleuss, and submitted in its improved condition by Siebe, Gorman and Co., Limited, has sufficient points of superiority to justify an award to its inventor. They, therefore, recommend the award of a gold medal to Mr. Henry A. Fleuss, who as long ago as 1883 received a gold medal from the Society of Arts, under the

Shaw Trust, for this apparatus in its original form. The committee also recommends to the Council that a second gold medal should be awarded to Mr. William Edward Garforth, in recognition of his long-continued and public-spirited endeavours to perfect and to secure the adoption in this country of rescue apparatus in mines, and also as an acknowledgment of the merits of the principles which he has applied to the apparatus he has himself devised, but which are equally applicable to all similar forms of rescue apparatus.

In addition to these two golds medals, the committee recommends to the Council the award of a silver medal for the Draeger apparatus submitted by Mr. Jacobson, and for the Meco apparatus submitted by the Mining Engineering Company, of Sheffield.

CAB SIGNALLING ON THE LONDON AND SOUTH-WESTERN RAILWAY.

A MONTH or two ago Rule 55 was in everybody's mouth; everyone knew that it was the duty of the guard or firemen to get down and walk back to the signal cabin near which his engine was drawn up to warn the signalman, and that a slight failure to comply with that rule had cost several lives. The rule has been brought into prominence again within the last few days by the request of a deputation to Mr. Buxton that it should be removed from the railway rules. All railwaymen recognise that the rule is troublesome and not very satisfactory, and ultimately some better plan will be found. The London and South-Western Railway is, indeed, already fitting a section of its line with a very simple electrical apparatus designed by Mr. Dugald Drummond, which not only acts as a fog signal by warning the driver, and even putting on his brakes, but also tells the signalman whenever a train, engine, or single vehicle is in a certain section. If this proves as successful in actual work as the experimental length which has been set up at Eastleigh promises, Rule 55 may soon be a thing of the past. We may also soon hear the last of the detonating fog signal, a very inefficient device used now for lack of anything better.

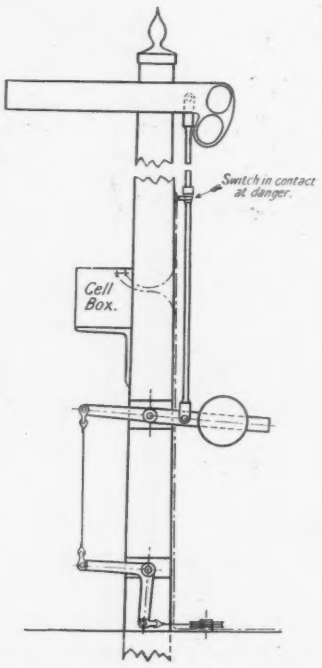


"THE ENGINEER"

L. & S.W. CAB SIGNAL

A diagram of Mr. Drummond's apparatus is given herewith. It can be divided into three parts for the purpose of description — first, the portion in the permanent way; secondly, the apparatus on the engine; and, lastly, the arrangement for warning the signalman. The apparatus in the permanent way consists of a length of light tee iron, curved at the ends, placed longitudinally between the rails and electrically insulated. In the plant in Eastleigh yard it is pivoted at the centre, and springs at each end keep it parallel with the rails. As far as we could judge from close attention to the action, there is no reason why it should not be permanently fixed. It stands, as shown in the drawings, slightly above the rail level. This bar forms part of an electric circuit, which is open when the signal is clear, but closed when it is at danger, and it is placed in advance of the signal by an amount determined by the nature of the traffic and the speed of the trains, so that the driver is warned before he reaches the signal. The switch is a very simple affair fixed on the rod operating the signal arm. The electrical circuit is completed through the rails.

Coming now to the apparatus on the engine we find first an electrically insulated contact piece suspended below the engine. It consists of a rigid vertical arm carrying transversely a number of thin flat hard brass plates which make a very flexible spring. This contact piece is so placed that the brass springs rub against the bar fixed in the permanent way and complete the electrical circuit. This it does, on account of its lightness, with no appreciable shock. In the cab in proximity to the driver is placed a box containing an electro-magnet which can operate a valve placed in a branch of the brake train pipe. The vacuum brake is used on the London and South-Western, and the opening of this valve admits air to the train pipe and so applies the brakes. If the Westinghouse brakes were employed the pressure air would be allowed to escape from the train pipe and the same result would be attained. In either case the air either rushing in or out is made to operate an audible signal, either a reed or a whistle, which calls the driver's attention to the fact that the signal is against him. The circuit may also be made, as shown in the drawing, to operate the steam whistle. To reset the valve and get the brakes off, the engine driver turns a little disc in the box already mentioned. Of course, if the signal is at clear the circuit is broken by the signal switch, no current passes through the collector, and nothing happens in the cab; there is no other indication that the signal is off, but since the brakes cannot be removed till the semaphore falls, the driver is unable to start until the signalman has given him the road. There is, of course, the possibility of a failure in the electric circuit. In that case the raising of the semaphore to danger would not give the usual signal in the cab. It is to be remarked, however, that the electrical device is supplementary to the ordinary signalling, and not intended to replace it. Its object is to ensure the safety of a train even if the driver is negligent. Moreover, by duplicating the electric circuit throughout the probability of failure from this cause could be reduced to very small proportions.



SIGNAL POST WITH ELECTRIC CONNECTIONS

The warning to the signalman that there is something on the line in the neighbourhood of the home signal—that is, the warning that obviates the necessity of Rule 55—is obtained by insulating a portion of the road and coupling the two rails to a distinctive bell in the signal cabin. A vehicle makes electrical contact between the two rails and causes the bell to ring and to continue ringing as long as it is there.

The whole apparatus is, it will be seen, extremely simple, and the short test piece in Eastleigh yard has been thoroughly experimented with and found to act excellently. It now remains to be seen if, in the portion which is being laid on the main line, any unforeseen difficulties arise.

EXPERIMENTS have been made in Germany with a view to ascertain the best means of preserving coal from deterioration after it has been mined. The coal experimented with consisted of 5in. lumps, vessels of about half gallon capacity being charged with it and provided with air-tight covers. The vessels were further filled either with water or with carbon dioxide, flue gases, or sulphurous acid vapours. Samples were taken and analysed after two weeks, three weeks, and six months; at the end of this period no further weathering seemed to occur. Parallel tests were made with coal exposed to the air. The different sorts of coal did not all behave equally; but, on the whole, it would appear from the results of these experiments that little is gained by keeping the coal in special atmospheres, or under water, although submarine storage has been reported as effective in other instances.

NEW WELL AT BEACONSFIELD.

A WELL which has recently been completed, and in the sinking of which a rather curious occurrence was experienced, has just been brought to our notice. The site of the boring is at Beaconsfield, and it is on the edge of the 400ft. contour. During the sinking operations it became evident that it was over the channel of a "swallow hole," which had become inactive and nearly entirely choked up when the valley was sufficiently eroded.

For those of our readers who are not acquainted with the meaning of the term "swallow hole" we cannot do better than quote from the recently issued book on "The Geology of Water Supply," by Mr. Horace B. Woodward, F.R.S.*:—

"Swallow holes, known also as 'swallet' or 'sink holes' are natural openings and channels, more or less funnel-shaped, and formed or enlarged by the action of water holding carbonic-acid gas in solution on permeable and fissured strata such as chalk and other limestones, notably the carboniferous limestone. Through these openings springs and streams are diverted underground."

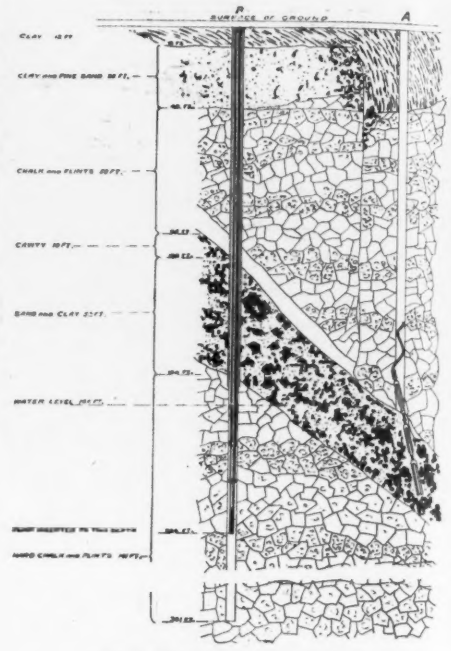


Fig. 1—SECTION OF BORE-HOLE

A sectional view of the boring is given in Fig. 1. Boring A was first commenced and all went well for the first 160ft. or so. After this, however, the tool, while still working freely, suddenly dropped and became inextricably jammed, so that it had to be abandoned at a depth of 179ft. A second boring B was started some 12ft. away, and this time precautions were taken to prevent a repetition of the first failure. At 98ft. from the surface the tool dropped a clear 10ft. without obstruction. Fifty-two feet of extremely soft sand and clay were then passed through before the chalk was again reached at 160ft. from the surface.

The sectional drawing, which is based on the actual conditions met with, suggests the probable cause of the failure in the first borehole. There are large numbers of swallow-holes in the neighbourhood, and the size of this particular example as evidenced by the clear space and by the thickness of the detritus, shows that originally, and before it became silted up the surface opening must have been extremely large. The piercing of a swallow hole and the proving of a cavity of this nature in the chalk are a rare occurrence. In this instance it has not interfered with the supply of water from the well, for on a

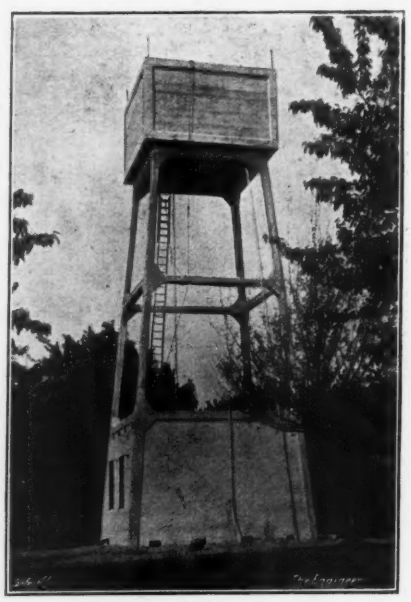
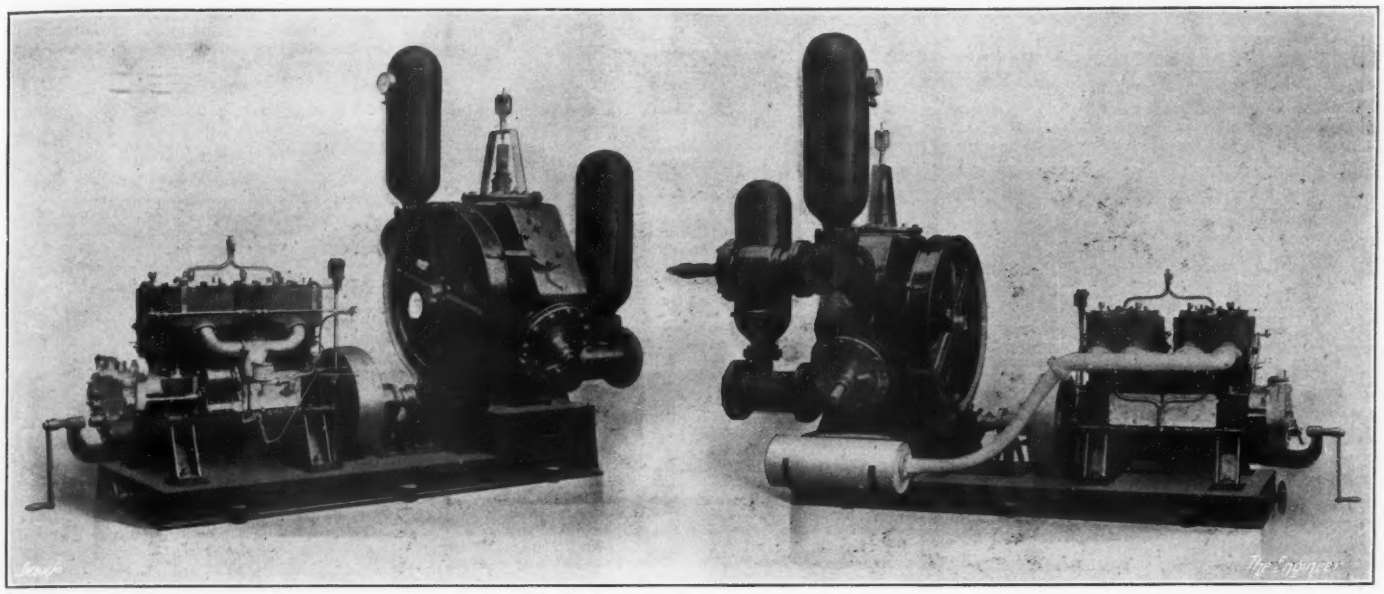


Fig. 2—FERRO-CONCRETE WELL-HEAD

* London: Edwin Arnold.

STATIONARY PETROL-DRIVEN FIRE PUMP

MERRYWEATHER AND SONS, LIMITED, GREENWICH, ENGINEERS



continuous test it yielded nearly 2000 gallons an hour of absolutely pure water. The borehole was taken down to 301ft. below the surface, and the pump suction arranged at a depth of 204ft. The normal water level stands at 166ft. Cast iron lining was taken down through the detritus well into the chalk below it.

The well was sunk on the Grange Estate, Beaconsfield, by the Perkins Macintosh Tool and Boring Company. The water is delivered into a 7000-gallon reinforced concrete tower, which is illustrated in the accompanying engraving, and which was carried out to the designs of the consulting engineers for the whole work, Hal Williams and Co., by the Patent Indented Steel Bar Company, Limited.

PETROL-DRIVEN FIRE PUMP.

A LARGE stationary petrol-driven pump of the "Hatfield" pattern has just been completed by Merryweather and Sons, Limited, of Greenwich, for a fire protective installation abroad. It is illustrated above and is of interest in that it is, we believe, the largest of its kind yet made, the pump having a capacity of 800 gallons per minute at high-pressure with a speed of 225 revolutions per minute. The petrol motor is of the four-cylinder vertical water-cooled type, as used on the firm's motor fire engines, and gives 80 brake horse-power, having cylinders each 6½in. diameter by 6½in. stroke. Duplicate systems of ignition are fitted, viz., high-tension magneto and battery and coil. A large welded steel petrol tank of a capacity of 24 gallons and a circulating water tank are provided.

The pump is driven through cone clutch and spur wheel gearing. The pump is of the reciprocating type, having three plungers arranged 120 deg. apart around a common crank shaft. The main casting is a cast iron. No barrels are fitted, the plungers, which are of gun-metal, working through packed glands directly in the valve chambers. This arrangement gives a minimum clearance between the plungers and the valves, thus enabling the pump to be used on a deep lift. Indeed, we understand that the pump will draw from a depth of 26ft. without priming. The plungers are 9in. in diameter and the stroke is 6in. Each plunger is fitted with a gun-metal tail rod working through a stuffing-box in the valve cover. A sight-feed lubricator is fixed over the vertical tail rod, through which the oil is conveyed to the crank pin and connecting-rod ends. The crank shaft is of steel and runs in long gun-metal bushes fixed in the end plates, and the connecting-rods are coupled to the plungers by hollow steel pins. A by-pass valve is fitted, by means of which connection can be established between suction and delivery passages so as to enable the apparatus to start readily against a head of water, and to maintain a steady jet in the event of the water supply being limited.

The whole is mounted on a cast iron bed-plate, and, as will be noticed, it is very compact, taking into account the large quantity of water delivered.

AT a recent meeting of the Royal Institution, Mr. T. Thorne Baker delivered a lecture on "Wireless Telegraphy and Aeroplanes." The airship, he said, was easy to deal with on account of its comparatively large carrying capacity, which enabled accumulators or a small dynamo to be carried for supplying electrical energy to the wireless apparatus. In the case of the aeroplane, however, weight was an all-important factor. Mr. Farman had obtained satisfactory results with his biplane by using two trailing aerials, each one consisting of rather thin wire about 100 m. in length. A similar Hertz arrangement had been applied by the lecturer to a Bristol biplane, no loose wires being used. In receiving wireless messages on aeroplanes, the chief difficulty was noise. Visible methods of receiving the wireless message had therefore to be adopted. Vibration was also a difficulty if the ordinary coherer were used, and an anti-vibration holder might be necessary. In the case of the Beta military airship wireless signals had been transmitted a distance of 50 miles. One of the most useful advances in wireless work was the conduction wireless telephone of Mr. A. W. Sharman; and remarkable possibilities were suggested by the attempt to employ the surface of water in place of the ether as a transmitting medium.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

NATIONAL INSURANCE AND THE CONTRACTOR.

SIR,—Will you allow me to bring before your readers the special hardship which the proposed National Insurance and Unemployment Bill inflicts upon contractors who have recently taken contracts which will extend over several years? It is contended by the framers of the measure that the employers will put the contributions they are compelled to make upon their prices, but this is impossible to a contractor who has a long contract unless some special provision is made. It is an open secret that most, if not all, of the large contracts that have been let recently have been let at unremunerative prices. Contractors have taken work to keep their staff, workmen, and plant going, with little hope of ultimate profit, and now a further impost, which will mean something between 2 to 2½ per cent. upon the wages bill, has been placed upon them, so that a large proportion of any small profit which may be secured will be swept away, or they may be compelled to provide a considerable sum to add to their loss. Last summer several large waterworks contracts were let, all of which will extend for four or five years. There must also be a number of builders who have taken asylums and other large buildings who will be subjected to this hardship. Cannot some method be adopted for voicing this matter and securing such protection as may be possible by means of some special clause or clauses inserted in the Bill which will except such works from the employers' contribution or secure some substantial contribution towards the expense of this measure from the constructing corporation or company? I should be glad if you could throw open your columns to this aspect of the measure, and beg to subscribe myself

June 16th. A WESTMINSTER CONTRACTOR.

THE VALUE OF A VACUUM.

SIR,—Referring to the recent articles dealing with the cost and value of a vacuum, it is thought that the following method of stating the case for high vacuum may make the point in dispute somewhat clearer.

Let us assume an ordinary triple-expansion marine engine, having low-pressure cylinder ports and exhaust pipe, designed for low steam speeds, working at constant revolutions, and with fixed cut-off.

Suppose, further, the vacuum varied from 22in. to 28in., and the resistance increased so as to absorb the increased power due to the higher vacuum. The reduced mean pressure, and with it the indicated horse-power, will, of course, increase with the increased vacuum. The amount of steam used, however, will be practically a constant quantity, so that the increased power will be directly due to the increased vacuum.

In Mr. Morison's paper there were described experiments made by Dr. Mellanby with a cross-compound engine, running at fixed revolutions, and constant cut-off. These experiments showed an increased steam consumption with increased vacuum, which was attributed by Dr. Mellanby to increased clearance loss, increased valve leakage, and greater condensation. Dr. Mellanby, however, stated that with a triple-expansion engine the effect of this loss would be much less marked, and, consequently, there would be little increase in the steam used per hour with increased vacuum.

Now consider the temperature of the feed-water or hotwell in each case. In any given engine there is always a drop between the temperature due to the vacuum in the condenser and the temperature of the feed-water, depending solely on the amount of air present in the condenser. In a fairly air-tight system this drop of temperature is small, amounting to only a few degrees; but in many cases the air leakage is enormous, and the corresponding drop of temperature very considerable.

Under fixed conditions the air leakage is constant, but would tend to increase with increase of vacuum. For the sake of argument, let us assume a reasonably air-tight system in which this increase of air leakage may be neglected, so that the drop of temperature with varying degrees of vacuum in the condenser would be practically constant. We may therefore in considering different vacua omit this constant and consider the temperature of the hotwell the same as the temperature due to the vacuum.

Suppose the engine working with steam of 180 lb. absolute pressure, having a temperature of 373 deg., and a total heat of about 1196 B.Th.U. At the different vacua the units of heat to be added to the feed-water in each case are as follows, the figures being taken from Marks and Davies' steam tables:—

Vacuum.	Total heat.	Temperature of hotwell.	Units of heat to be added to the feed-water.
22	1196	152	1044
24	1196	141	10 5
26	1196	126	1070
28	1196	102	1094

From this it is seen that increase of vacuum from 22in. to 28in. means a loss of heat in feed-water temperature of 50 deg., which is roughly equivalent to 4.5 per cent. of the total heat of the steam.

Now consider the gain in power. Bearing in mind that the back pressure line has been dropped 6in., the gain in power is roughly equivalent to an extra 3 lb. pressure on the low-pressure piston. If the reduced mean pressure were 30 lb., then the increased power would be 10 per cent. In many marine engines the reduced mean pressure is less than 30 lb., and the percentage gain would be greater. Against this gain there is a loss of 4.5 per cent. in temperature of feed-water, but according to Mr. Morison's system this loss of 4.5 is minimised or altogether eliminated by utilising exhaust steam from the auxiliaries. In the simplest case, where only an evaporator and steering engine are fitted, it can be shown that the steam from these alone can heat the feed-water through 70 deg. to about 170 deg., *i.e.*, to a point as high as the ordinary ram-feed pumps will work. In larger installations with more auxiliaries the feed water can be raised to 212 deg., or higher by the same means. In this way the loss by adoption of high vacuum is entirely wiped out, though the gain by increased pressure on the low-pressure piston remains, and has been shown to amount to about 10 per cent. between 22in. and 28in. vacuum with the assumptions made. In actual practice the gain will not probably be quite so much, but certainly would amount to 10 per cent. with an increase of vacuum from 20in. to 28in.

It may here be pointed out that the percentage gain depends upon the reduced mean pressure, and is greater as this pressure is less. This means that the larger the low-pressure cylinder for a given power, the greater is the gain from higher vacuum.

June 16th. A. SCOTT YOUNGER.

SIR,—On reading the leading article in your issue of June 9th on "The Value of a Vacuum," I notice that for the engines of the Djerissa you have assumed that there are two low-pressure cylinders.

This is not so, for the Djerissa's engines are triple-expansion, with one low-pressure cylinder, and the percentage gain for 2in. of vacuum on your basis of comparison for the Djerissa will thus be 3.9 per cent., instead of 7.8 per cent. This saving of 3.9 per cent. for the Djerissa is in excess of the saving of 2.6 per cent. of the Indrabarah. The difference—1.3 per cent.—may easily be accounted for by inaccuracies in indicating, or, as you suggest, by different cylinder proportions.

At the same time, it is of interest to note that in the case of the steam turbine the saving due to vacuum increases as the vacuum increases. The proportion of gain as given by Mr. Gerald Stoney in his Cantor Lectures before the Royal Society of Arts, March 22nd and 29th and April 5th, 1909, are as follows:—Between 25in. and 26in. or 26in. and 27in. there is a gain of about 4 per cent.; a further gain of 5 per cent. is made with the vacuum increased to 28in., and a still further gain of 6 to 7 per cent. when it is increased to 29in.

In the case of the reciprocating engine it would be impossible to have the ports in the slide valve and in the cylinder sufficiently large to accommodate the large volume of steam at such a low press as ½ lb. absolute—corresponding to 29in.—and so obtain the greatest possible efficiency for the low-pressure engine. In practice the ports in the low-pressure are made as large as practicable, so as to reduce the back pressure to a minimum, and thereby increase the efficiency of the low-pressure engine.

West Hartlepool, June 14th. ROBERT P. FINLAY.

JUNIOR INSTITUTION OF ENGINEERS.

SUMMER MEETING, 1911.

Saturday morning, 29th July.—10 a.m.: Members from London leave Liverpool-street (Great Eastern Railway) for Felixstowe.

Sunday.—Felixstowe.

Monday.—Ipswich: Visit Messrs. Ransomes and Rapier's works in the morning. Luncheon by invitation of the firm. Afternoon: Visit the works of Messrs. Ransomes, Sims and Jefferies. In evening, leave Ipswich for Norwich.

Tuesday.—Norwich: Visit in the morning the Norwich works of the British Gas Light Company, for inspection of new system of carbonisation by means of deep chamber retorts. In afternoon the cathedral and castle (including museum), may be visited.

Wednesday.—A day on the Broads.

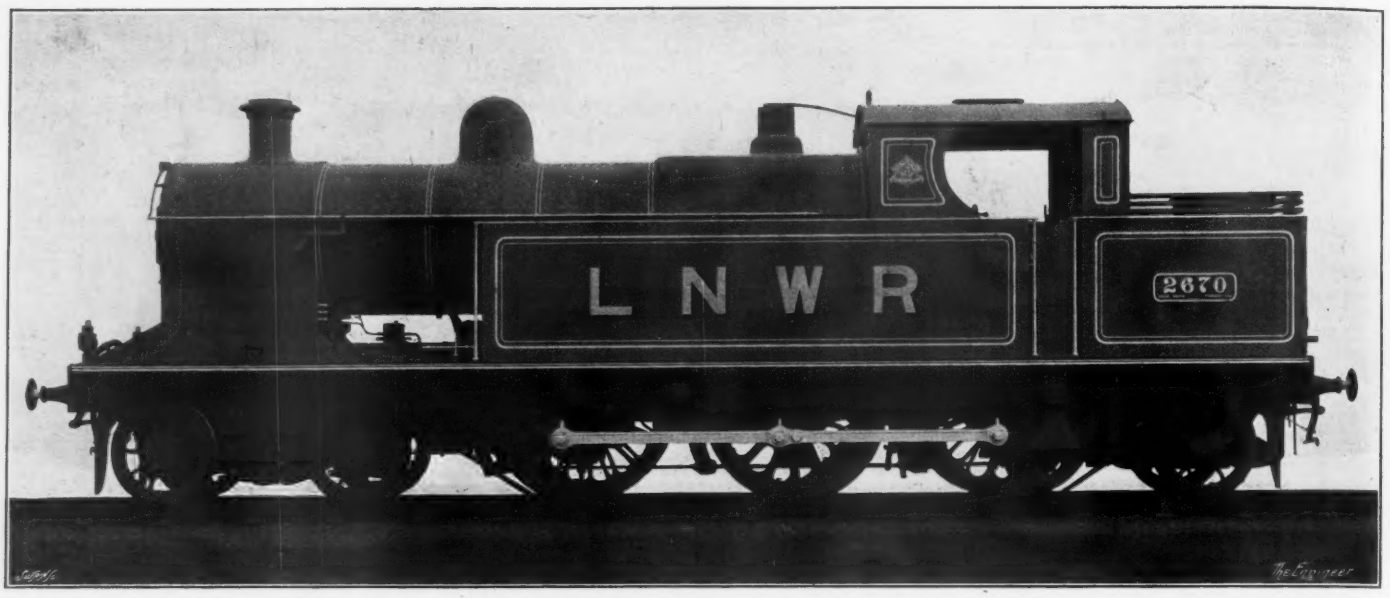
Thursday.—Morning: Visit the works of Messrs. J. and J. Colman, through arrangements kindly made by the Right Hon. James Stuart, P.C., M.A., LL.D. In the afternoon, proceed to Cambridge.

Friday.—Cambridge: Visit the engineering laboratories and workshops and the colleges, through arrangements kindly made by the President, Sir J. J. Thomson, F.R.S. In the evening the Institution's summer dinner will be held at the University Arms Hotel, the President in the chair.

Saturday.—Visit places of general interest at Cambridge. Members returning to London leave at 5.10 p.m., arriving Liverpool-street at 7.21 p.m.

SUPERHEATER SIDE-TANK PASSENGER ENGINE, LONDON AND NORTH-WESTERN RAILWAY

C. J. BOWEN COOKE. M. INST. C.E., CREWE, ENGINEER



SIDE-TANK PASSENGER ENGINES, L. & N.W.R.

ON this page and in our two-page Supplement we illustrate a new type of 4–6–2 side-tank passenger engine fitted with a superheater, recently designed by Mr. C. J. B. Cooke for the London and North-Western Railway, and constructed at the Crewe workshops.

The ever-increasing amount of suburban traffic which has to be handled by the railways serving large cities has given a powerful stimulus to the development of the fast side-tank engine, as it is generally recognised that this class of locomotive is more suitable than any other for such work. The additional adhesion obtained with such engines by reason of their carrying their own supply of water and coal is a strong point in favour of their employment for suburban traffic. As we have pointed out in our recent series of articles on "Passenger Tank Engines," there is also a wide tendency to-day to employ such engines not only for suburban traffic but on other work of quite a different nature, including even the hauling of semi-express trains. In the article of the above-named series appearing in our issue of September 23rd, 1910, we illustrated and described the "Precursor" tank engine designed by the late Mr. Whale. These engines are of the 4–4–2 type with driving wheels 6ft. in diameter. It has been found that their axle loads—39½ tons on the coupled wheels—and their weight per foot run are such as to restrict their use to certain parts of the line. Mr. Whale's successor at Crewe has designed the class of engine herewith illustrated in order to secure decreased stresses on the bridges and at the same time obtain an increased adhesive force. The average axle load with these engines is just under 13 tons; in the "Precursor" tank engines of Mr. Whale's design it is 15 tons. It will be seen, however, from the particulars given at the end of this account that the total weight on the coupled wheels of the new engines is 4½ tons in excess of what it is in the old. Like the "Precursor" type, Mr. Cooke's new engines are intended not only for suburban traffic, but for comparatively long distance passenger or goods runs. The engines of this class have, we understand, already given great satisfaction with express passenger trains and heavy main line goods trains. They may, in fact, be briefly described as "general utility" engines.

The front end of the engine is carried on a four-wheeled bogie truck, with wheels 3ft. 3in. in diameter, and the rear end on a radial axle having the same diameter of wheels. The six-coupled wheels are 5ft. 8½in. in diameter when new. The cylinders are inside the frames, and have a diameter of 20in., with a stroke of 26in. Piston valves, 8in. in diameter, driven by Joy valve gear, distribute steam to the cylinders. The details of the valve gear are as follows:—

Travel of valves	5⅛in.
Lap	1¼in.
Steam lead	7/32in.
Exhaust clearance	7/32in.

Both the piston and the piston valves are fitted with tail rods.

The boiler barrel is 4ft. 6½in. in mean external diameter, and is composed of one single plate, 10ft. 9in. in length. The fire-box is of the Belpaire type. The superheater is of the return bend pattern, and comprises twenty-one sets of tubes. A variable blast pipe, provision for heating the feed-water by means of the exhaust steam, hot-water injectors, and a water-scoop apparatus on the rear tank are further innovations in the design. It will be seen, too, from the general drawing that the engines are fitted with balanced crank webs, the crank shaft being of the built-up pattern, with hollow crank pins. The automatic vacuum brake is fitted, all the coupled wheels being provided with brake blocks. The brakes can, however, be controlled independently by hand from the fireman's position on the footplate.

Of the first set of engines of this class to be built ten are provided with superheaters and 20in. cylinders. The succeeding ten work on saturated steam, and have 18½in. cylinders. It is intended to test these engines under identical conditions, so as to arrive at some definite idea as to the value of superheating. The economy resulting from the use of feed-water heating and a variable blast pipe will also be investigated.

Below we give some further particulars of these engines:—

Working-pressure	175 lb. per sq. inch
Heating surface—	
115 tubes, 1¾in. ext. diameter	638.6 sq. ft.
21 tubes, 5in. ext. diameter	308.8 ,,
21 sets of superheater tubes	248.2 ,,
Fire-box	138.0 ,,
Total	1333.6 ,,
Grate area	23.0 ,,
Total wheel base	33ft. 9in.
Weight in working order—	
On leading truck	21 tons
On driving wheels	16 tons 10 cwt.
On intermediate wheels	14 tons
On trailing coupled wheels	13 tons 10 cwt.
On trailing radial wheels	12 tons
Total	77 tons
Water capacity of tanks	1700 gallons
Coal capacity	3 tons

FORTHCOMING ENGAGEMENTS.

SATURDAY, JUNE 24TH.

GEOLOGISTS' ASSOCIATION OF LONDON.—Excursion to Bushey, Oxhey, and Watford Heath. Leaving Euston at 2.20 p.m.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to Lillie Bridge Works of London Underground Electric Railways, S.W. 3 p.m.

TUESDAY, JUNE 27TH.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. Meeting of Contributors to the Benevolent Fund. 7.30 p.m.

TUESDAY, JUNE 27TH, TO FRIDAY, JUNE 30TH.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—Sixteenth Annual Convention at Brighton. For programme see page 490 *ante*.

WEDNESDAY, JUNE 28TH.

INSTITUTION OF CIVIL ENGINEERS.—Conferences on Education of Engineers—see programme, page 594. The nineteenth "James Forrest" Lecture by Frederick Henry Hatch, Ph.D., M. Inst. C.E., "Gold Mining in the Transvaal." 8 p.m.

THURSDAY, JUNE 29TH.

THE INSTITUTION OF CIVIL ENGINEERS.—Confereuces on Education of Engineers—see programme, page 594. The Annual Conversazione will be held in the Royal Albert Hall, at 8.30 p.m.

FRIDAY, JUNE 30TH.

PHYSICAL SOCIETY OF LONDON.—The Imperial College of Science. "On the Effect of a Narrow Saw-cut in the Edge of a Conducting Strip on the Stream Lines in the Strip and on the Resistance of the Strip," Professor C. H. Lees, F.R.S. "The Capacity Coefficients of Spherical Electrodes," Dr. A. Russel. "Exhibition of the Benkö Primary Battery," Mr. W. R. Cooper. 5 p.m. This meeting takes the place of the one previously arranged for June 23rd, which is cancelled.

SATURDAY, JULY 1ST.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to Messrs. George Kent's Hydraulic Engineering Works, Biscot-road, Luton, and the Straw Hat Factories of Messrs. Dillingham and Son, or of Mr. F. E. Shoosmith, both in Upper George-street, Luton.

MONDAY, JULY 3RD, TO FRIDAY, JULY 7TH.

INSTITUTION OF NAVAL ARCHITECTS.—Jubilee meetings. For programme see page 627 *ante*.

THURSDAY, JULY 6TH.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Conversazione to be held at the Natural History Museum, S.W. 9 to 11.30 p.m.

WEDNESDAY, JULY 19TH.

THE STEPHENSON SOCIETY.—Visit to Swindon Locomotive and Carriage Works (Great Western Railway).

THURSDAY, JULY 20TH.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to the Great Eastern Railway Locomotive Works at Stratford, E. Leave Liverpool-street 1.52 p.m. (platform No. 13).

MONDAY, JULY 24TH, TO SATURDAY, JULY 29TH.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Zurich Meeting, 1911. For programme see page 630 *ante*.

SATURDAY, JULY 29TH, TO SATURDAY, AUGUST 5TH.

JUNIOR INSTITUTION OF ENGINEERS.—Summer Meeting at East Anglia. For programme see page 653.

THURSDAY, AUGUST 3RD, TO MONDAY, AUGUST 21ST.

GEOLOGISTS' ASSOCIATION OF LONDON.—An Excursion to the Bergen District, Norway. Leaving King's Cross on August 3rd by special boat train for Hull.

SATURDAY, SEPT. 9TH, TO WEDNESDAY, SEPT. 20TH.

GEOLOGISTS' ASSOCIATION OF LONDON.—September Long Excursion. The first part of the excursion will be devoted to a study of the Geology of Lochaber, including Glens Nevis, Roy and Coe, and Fort William will be the headquarters. The second part of the excursion will be devoted to the Geology of the Broadford district of the Island of Skye, and the headquarters will be at Broadford. Full particulars of excursion may be obtained from Mr. Alfred D. Young, 17, Vicars-hill, Lewisham, S.E.

WEDNESDAY, SEPT. 13TH, THURSDAY, SEPT. 14TH, AND FRIDAY, SEPT. 15TH.

THE INSTITUTION OF MINING ENGINEERS.—Cardiff. Annual general meeting. Further particulars later.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

Finished Iron Business.

BAR makers are doing well, and the market generally is not quite so sensitive to the demoralising influences of under-selling of low-grade iron by continental competitors. Unmarked bars for nut, bolt, and fencing purposes do not fetch more than £6, less discount, and, seeing that this is much above the Belgian price, the home maker finds his trade very much circumscribed. Merchant qualities are selling a little more freely, but buyers hesitate to give more than £6 5s. Marked bars remain at the £8 basis. North Staffordshire crown bars are £6 15s. delivered at ports.

Pig Iron.

Pig iron producers give no better accounts of their experience. Small sales continue to be made at the recent quotations, but while there has been a little more inquiry during the past few days consumers have shown no eagerness to buy forward. Prices of all branches are firm, and indications point to an upward rather than a downward movement. The employees of a Northamptonshire firm have come out on strike, and in consequence two furnaces have been damped down. Should this dispute continue the production of pig iron will be appreciably affected, and the development is bound to help the hardening tendency of prices. Quotations are:—Forge pig iron: Staffordshire common, 49s.; part-mine, 50s. to 50s. 6d.; best all-mine forge, 85s; foundry, 90s.; cold blast, 115s.; Northamptonshire, 47s. to 48s.; Derbyshire, 50s. to 51s.; North Staffordshire forge, 51s. to 52s.; best, 58s. to 59s.

Half Product and Rolled Steel.

Steel is not so strong as it was a short time ago. Maker in this district are well off, though activity runs largely on semi producers, in which a very stiff continental competition has to be faced. Siemens bars and billets rule at £4 17s. 6d. to £5, and Bessemer £4 15s. to £4 17s. 6d. These prices approximate too nearly to those of the German dumpers to allow the latter much rope, though the imports on old contracts are of considerable magnitude. Steel strip and hoops realise £6 17s. 6d. to £7 7s. 6d., according to quality. Rolled steelmasters report a marked increase of demand for structural steel, and some mills have made especially heavy bookings. Apparently there is an increasing disposition to regard the forthcoming International Steel Conference at Brussels as important, and it is thought that some sort of international agreement may possibly result therefrom.

Wrought Iron Tube Trade.

In the wrought iron and steel tube trade a fairly large output is being maintained, although at prices not considered satisfactory. There are great complaints in this very important industrial district of keen international competition. America in particular is dumping a large quantity of tubes, not so much into this country as into those consuming European markets which formerly took a very fair share of the British output.

Railway Rolling Stock.

The railway rolling stock trade is by no means as good as it has been in some preceding years, but this is largely due to the falling off in the requirements of the Argentine and other South American railways. However, a fair amount of work has been available from other sources, and although competition is still exceedingly keen amongst home manufacturers the Birmingham rolling stock establishments are steadily employed. The Indian

State Railways have given out a number of good orders for wagons and other equipments.

Motor Engineering.

There has been some slackening of activity in the motor car trade, but most firms have still a lot of work in hand, and more than in any previous year at this time. Important extensions are being made at one of the Birmingham works. The export trade continues good, and very heavy shipments were returned for May, the value being £227,600, compared with £192,000 last year, and less than £100,000 two years ago. For the five completed months this year the trade is valued at £1,249,000, against £869,000 and £484,000 last year and the year before respectively.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Tuesday.

Firm Tone in Pig Iron Maintained.

THE better tone in pig iron noted last week has been maintained, and some kinds, especially Cleveland, are ruling higher. There is no change to note in copper and lead, but tin continues to decline. Quotations:—Pig iron: Lincolnshire, No. 3 foundry, 53s.; Staffordshire, nominal, 53s. 6d. to 54s. 6d.; Derbyshire, 53s. 6d. to 54s.; Northamptonshire, 54s. 6d. to 54s. 9d.; Middlesbrough, open brands, 55s. 4d. to 55s. 10d., according to delivery. Scotch: Gartsherrie, 61s.; Glengarnock, 59s.; Eglinton, 58s. to 58s. 6d., delivered Manchester. West Coast hematite, 64s. to 64s. 6d., f.o.t.; East Coast ditto, 62s. 6d. to 63s., f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 57s.; Eglinton, 56s. to 56s. 6d. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 58s.; Eglinton, 57s. to 57s. 6d. Finished iron: Bars, £6 15s.; hoops, £7 7s. 6d.; sheets, £8 to £8 2s. 6d. Steel: Bars, £6 10s. to £7; Lancashire hoops, £7 7s. 6d.; Staffordshire, £7 7s. 6d.; sheets, £8 to £8 5s.; boiler plates, £7 15s.; plates for tank, girder, and bridge work, £7 to £7 5s.; English billets, £5 to £5 5s.; foreign ditto, £4 10s. to £4 12s. 6d.; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £70; tough ingots, £60; best selected, £60 per ton; copper tubes, 8¾d. to 8¼d.; brass tubes, 6½d.; condenser, 7¼d.; brazed brass tubes, 8¼d.; rolled brass, 6¼d.; brass wire, 6¼d.; brass turning rods, 6¼d.; yellow metal, 6d. to 6¼d. per lb. Sheet lead, £16 to £16 5s. per ton. English tin ingots, £196 per ton.

The Lancashire Coal Trade.

There is no change to note on the week. Prices of engine fuel and slack generally are steady.

Shuttle Kissing.

In his annual report on cotton factories, Mr. Arthur Whitelegge, Chief Inspector of Factories, alludes to the practice of "shuttle kissing" which was recently brought into prominence by a report issued by the Medical Officer of Health for Bacup, who attributed three deaths from phthisis to this cause. An attempt is being made to put a stop to this objectionable but universal practice on the part of the weavers of sucking the yarn through the eyelet of the shuttle in order to thread it. So far the inventions to overcome the "kissing" have taken two forms, a mechanical sucker and a contrivance for threading without suction, but it will be difficult to persuade the weavers to adopt any method that is not as quick and as easy as the present one. The report states that there is a marked decrease in the number of card-cylinder accidents due to the steps taken to provide automatic locking motions on these machines. Steps are being taken to prevent accidents with self-acting mules which have been frequently brought about by the workers being trapped between the carriage and the stops. An increase in the number of shuttle accidents is reported, partly due, it is thought, to more looms being in use and to the speeding up of some of the older and slower looms. Investigation suggests that there is little to choose between the fixed and automatic guards. There is a reduction in the number of accidents while cleaning machinery in motion.

Manchester Gas Supply.

The total length of mains now laid, according to the report of the Gas Committee published last week, is 948¾ miles, an increase of nearly eleven miles over the previous year. On March 31st last the number of gas engines supplied with fuel by the corporation mains was 1573, compared with 1613 in the previous year, a reduction due, no doubt, to the increasing adoption of the electric motor in factories. The quantity of gas consumed by these engines was 380,994,000 cubic feet, or an increase over the previous year, no doubt due to improved trade. Commencing on June 25th next the price charged for gas used for manufacturing purposes within the city will be reduced from 2s. 3d. to 2s. per 1000 cubic feet, provided that the annual consumption is not less than 500,000 cubic feet.

New Art Gallery Designs.

The City Council, on the advice of Mr. Reginald Blomfield, A.R.A., in conjunction with the City Architect, Mr. H. Price, have selected ten designs prepared by architects who have taken part in the competition. The architects are as follows:—Messrs. H. P. Adams and C. H. Holden, Mr. Robert Atkinson, Messrs. Bradshaw and Gass and Arthur J. Hope, Messrs. Cooper and Slater, Messrs. Crouch Butler and Savage, Mr. R. F. Farrar, Messrs. A. G. Henderson and J. R. Hacking, Mr. F. W. Simon, Messrs. Warwick and Hall, and Messrs. Thomas Worthington and Son. The sum of 100 guineas has been paid to each of the authors of the successful designs. Each of these competitors will proceed to complete his design in the light of the further instructions received, and the completed designs will have to be submitted by September 16th next.

BARROW-IN-FURNESS, Tuesday.

Hematite.

There is a quiet tone in the hematite pig iron market, and little new business is being done just at present. The general requirements of consumers are not by any means large, and they are content to deal on the hand-to-mouth principle, ordering just sufficient iron to tide them over their present wants. This applies both to local and general home users. Little is on offer outside the country, although some special qualities of iron have been dispatched of late to Canada. Prices are weaker, with mixed numbers of Bessemer iron at 62s. per ton net f.o.b. This quotation is, however, quite nominal. For special makes of iron the demand, if small, continues to be steady, and those smelters who have given their attention to this branch of the trade have benefited considerably. The current rate for this iron is about 70s. per ton. In warrants there is nothing being done. Sellers are quoting about 62s. per ton net cash, with buyers offering 62s. per ton. The make of iron in West Cumberland is being materially decreased.

Iron Ore.

For iron ore there is a steady if rather quiet demand on local account. A good business has been done on account of Scotch smelters, and the ore is being sent from Furness mines *viâ* Barrow, and also from the Cleator Moor district through West Cumberland ports. The rate of output at the mines is unchanged. Prices run much the same, with good average sorts at 10s. to 12s., and the best ores are at 19s. 6d. per ton net at mines. Spanish ores are in steady demand with best sorts quoted up to 20s. per ton delivered to West Coast furnaces. Last week there arrived in Barrow from Les Falaises the s.s. Oteren with 1500 tons and the s.s. Torbay with 2100 tons of ore.

Steel.

The holidays are being observed in the steel trade, and during the whole of this week the plant of the Barrow Steel Company is doing nothing, and there is equal quietness in West Cumberland. The general demand for steel is quiet, and makers complain that prices are such that much of the business that is being offered cannot be taken on, if a profit is to be made. This applies to rails, but more especially to steel shipbuilding material. Heavy sections of rails are at £5 12s. 6d. and ship plates at £6 12s. 6d. per ton.

Shipbuilding and Engineering.

Both these trades are full up with work and will remain busy for a long time to come. The Chinese cruiser being built at Barrow will be launched about the 15th of next month.

Shipping.

The shipping trade is quietly employed both as regards iron and steel. The import trade, too, is quiet.

Fuel.

For coal the demand is light, and good steam sorts are at 11s. to 15s. 6d. per ton delivered. Coke is in steady demand at 22s. per ton delivered for East Coast sorts.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

General Conditions.

OWING to the Coronation holiday necessitating a stoppage of work on Thursday, many of the local works have suspended operations in their steelmaking departments the whole of the week, as the cost and time of relighting on Friday would scarcely be repaid by the few working hours left at the end of the week. In general, the holiday feeling abroad has curtailed business to a very large extent, and, moreover, stock-taking at many of the works and the usual quietude at the end of the half year are additional reasons for the present inactivity in the market for iron and steel. Manufacturers are fairly confident that the next half year will witness a revival of activity. As a rule, there is more work in hand at the moment than was the case a year ago, and prospects are certainly much brighter. Buying on Indian account is healthier, and it is thought extremely probable that a large weight of material has to be placed on home railway account, although the home railways are displaying a very cautious policy. That trade is much more active abroad seems to be proved by the well-sustained demand for specialities, particularly high-speed steel and agricultural requisites, while the export of cutlery and plate is exceedingly brisk. The United States demand has fluctuated considerably throughout the year, but there are not wanting signs of an improvement in that market.

The Coal Trade.

The output of coal has been on a limited scale this week, owing to the miners' annual demonstration on Monday and the Coronation festivities, the result being that very few of the pits were able to get anything like a full complement of men. The demand has kept up fairly well, and the requirements of the home markets and for shipment have enabled stocks to be cleared off. This being the case, it is hoped that the market will respond to firmer prices over the rest of the shipping season, particularly as some important continental buyers have not yet secured their supplies. Prices remain at 8s. 6d. to 8s. 9d. per ton for best South Yorkshire hards. In their annual report John Brown and Co. announce the probability of their opening out the valuable Rossington coalfield, near Doncaster, in conjunction with another company.

House Coal.

Business in house coals is very quiet, but prices are remarkably well maintained. A large number of inquiries are in the market for quotations for renewals of contracts for twelve months, to the end of June, 1912. Collieries are insisting with some measure of success, on the same prices as those obtained for the expiring contracts, for it is contended that recent legislation has enhanced costs to a serious extent, and that the new Mines Bill, if passed, will further increase the cost of production. On the other hand, merchants are asking for a reduction on the ground that during the past twelve months open market prices were occasionally very much below contract rates.

Slacks and Gas Coal.

Considering the large reduction in outputs at house coal pits, slacks, while firm in price, show little upward tendency. Probably the holidays have checked the demand. Quotations:—Best washed smalls, 5s. 6d. to 6s.; best hard slacks, 5s. 6d. to 5s. 9d.; seconds, 4s. to 4s. 3d. Gas coal shows little change, although an improved tonnage has been going out recently.

Pig Iron.

Business is practically at a standstill in the pig iron market, and deliveries have naturally been greatly curtailed during the week. The prices ruling before the holidays appear to be still operative. Quotations: Lincolnshire No. 3 foundry, 50s. 6d.; ditto forge, mottled and white, 49s. 6d.; ditto basic, 52s; Derbyshire foundry, 50s. to 51s.; ditto forge, 48s. to 49s. 6d., all per ton net delivered Sheffield or Rotherham. East Coast hematite mixed numbers, 68s. 6d. net. Parcels of cheap Belgian billets have recently changed hands at 87s. delivered, and local producers of dead soft billets have been compelled in consequence to reduce their prices.

The Steel Trades.

The holiday interruption this week, following so closely on Whit week, has undoubtedly caused a good deal of inconvenience to many departments, which are unusually full of orders. This applies particularly to the armour plate shops and to makers with a strong overseas connection in many kinds of steel tools and parts. On the other hand, specifications have been falling off from home engineers, but this too is largely attributed to the holidays.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

IT is a long time since the Cleveland pig iron market was so buoyant in tone as it has been during the last ten days; quite a change has come over business in this branch, and there is more firmness in prices than has been known of late. Producers are reported to have secured good orders, and have therefore become somewhat independent in the matter of prices; they are are not so ready as they have been for months to follow the fluctuations in the prices of warrants—at least, not when the movement has been downward. It is reported that makers have reduced their stocks very considerably, but that is a fact which cannot very well be verified, as no figures are forthcoming. However, there is no doubt of the fact that the stock of Cleveland pig iron in Connal's public store is now being steadily reduced, and that has a strengthening influence on the market. For three years the stock has been rapidly increasing, and has risen from under 48,000 tons at June 30th, 1908, to 564,000 tons at the close of last month. There appeared to be every likelihood that 600,000 tons would be reported in a few days, but this month there has set in a reduction, and on Monday last only 589,381 tons were held, a decrease for the month of over 5600 tons—the first time there has been a decrease over the month in any month for about three years. Every day last week some decrease in the stock of No. 3 Cleveland pig iron in Connal's store had to be recorded, and as the shipments have been only moderate this month it must be inferred that there is more activity in the local finished iron and steel trades, and that they are using more pig iron, which indeed is the case, as mills which have lately been running irregularly are now in full operation. There will be a smaller production of pig iron this week, for the blast furnaces will not be working on Thursday, it having been decided to suspend operations for the Coronation, and that will reduce the output of pig iron in the district by at least 10,000 tons, besides which production will be interfered with for some days, in that the furnaces will not be making their usual proportion of the higher qualities, and less No. 3 than usual will be forthcoming. Cleveland warrants, which last week reached 46s. 6½d. cash buyers, is back this week to 46s. 4½d., but that has not led to makers reducing the quotations for No. 3 Cleveland pig iron, for they have kept them at 46s. 9d. per ton for prompt f.o.b. delivery, with 50s. 3d. for No. 1, 46s. 3d. for Nos. 4 foundry and 4 forge, and 46s. for mottled and white, with 6d. more for delivery over the next two months.

Hematite Pig Iron.

Though the amount of business done in East Coast hematite pig iron this week is small the situation of the ironmasters producing this description of pig iron is satisfactory, and the outlook must be described as encouraging, for almost all branches of the iron and steel industries which are consumers of hematite iron have good prospects, more particularly the plate and angle manufacturers, who are profiting by the unprecedented activity of the shipbuilding industry, which is likely to be maintained for months to come; indeed, that is guaranteed by the amount of work on the books of the shipbuilders. That being so, it is rather strange to see prices of hematite pig iron failing to rise, especially when there is little stock in the hands of makers and none at all in the public warrant stores. Small lots, however, in the possession of second hands are to be had at lower prices than the makers will accept, and this prevents quotations rising. Mixed numbers are quoted by producers for early delivery at 62s. per ton, but second hands have accepted 61s. 6d. per ton for immediate delivery. They would not, however, enter into contracts for supplies over a period at any such figure, nor would makers at 62s., for it is said that this would not cover cost of production, though that has been recently reduced.

Ore and Coke.

Merchants keep up the price of Rubio ore very firmly, but they cannot well adopt any other course, because the Spaniards will not reduce their quotations, and they are the masters of the situation. The general quotation for Rubio ore ex ship Tees is 20s. per ton, but no one will pay it, and business in buying and selling foreign ore is practically at a standstill at present. Consumers have plenty of ore already bought and can afford to wait. Even the strike of seamen, which so far has not materially affected this district, will not inconvenience the users of foreign ore in the North of England unless it lasts for some weeks—and there is not much probability of that—for stocks of ore at most pig iron works are large. There does not appear to have been more than a single sale of Rubio ore at 19s., and that was in special circumstances, so that it is not regarded as fixing the price for the whole market. One thing cheap the ironmasters can secure is coke, that is relatively lower in value than pig iron. Though the production has been reduced there is still too much being made, and producers are keen to get rid of it, because its quality will not improve with keeping. If there were not the profits on the by-products so much coke would not be made, and it would be possible to maintain the prices. Before the introduction of the patent ovens there was no temptation to keep the output of coke in excess of requirements. It is, of course, better for the ironmasters that this cheap coke should be forthcoming, and it is several years since they could get it at as low a figure as is reported to-day.

Manufactured Iron and Steel.

Business is steadily becoming more favourable for producers of finished iron and steel, and they report more sanguinely about position and prospects. The improvement is recognised when it is stated that most of the manufacturers could not afford to give both the Whitsuntide holidays and the Coronation holidays, and the former were therefore not observed; there were too many pressing orders in hand. This week at nearly all the establishments Thursday, Friday, and Saturday will be observed as holidays—it is thought hardly worth while to light up for the two last days of the week, though one of the leading rail making firms is to stop for Thursday only. There is a strong improvement in the rail trade, and it would seem as if a general revival of railway enterprise is once more in progress. It is a considerable time since there was so much demand for all materials used in railway construction, and also for rolling stock, and it is not likely now that lower prices for these will rule. Good exports of rails are now reported from this district, though less is being forwarded to South America than was the case last and the previous years. The quotation for heavy steel rails is £5 12s. 6d., for cast iron railway chairs £3 12s. 6d., and for steel sleepers £6 15s., all net f.o.b. Nearly all the sleepers that are required are for shipment. Only small quantities are wanted locally. The fact is they have not answered very well at any rate on the North-Eastern Railway, because coke breeze was used for ballasting the line, and that material caused rapid corrosion of the metal. Now, however, the company is beginning to use limestone for ballasting, and that may enable it to use metal sleepers again. The company has acquired a limestone quarry, and has put down plant at several points for breaking the limestone which it will need into suitable sizes. The main line between York and Newcastle is being dealt with first. A resumption of the local use of steel sleepers would be of great benefit to Teesside makers. The production of steelp lates in this district is the largest ever known, though all the plant is not in operation, the Moor Works of the South Durham Steel and Iron Company at Stockton having been idle since the latter part of 1907. But the company is producing more material with its two other works, the Stockton Malleable and the West Hartlepool, in operation than it ever did previously with three establishments. All the other plate-making works are running to their fullest capacity, and makers are adhering firmly to £6 15s., less 2½ per cent., for steel ship plates, while iron ship plates are at £6 12s. 6d., less 2½ per cent. Steel ship angles are firm at £6 7s. 6d.; iron ship angles at £7, both less 2½ per cent. f.o.t. Iron bars are at £7, and steel bars at £6 5s., both less 2½ per cent. f.o.t. Steel hoops are at £6 12s. 6d.; steel strip at £6 10s.; steel joists at £6 7s. 6d.; and steel sheets at £7 10s., all less 2½ per cent. f.o.t. Galvanised and corrugated steel sheets are at £10 15s. for 24 gauge, less 4 per cent. f.o.b.; and local works are very well occupied, more fully than perhaps those of any other district. They are therefore doing better in the way of prices.

Coal and Coke.

Business in the coal trade of the North-East of England has improved lately, and has profited by the labour troubles in South Wales, where the supply has in consequence been reduced by strikes. More especially has this been experienced in the bunker coal business, and this is likely to have a good influence on business in this district when the labour difficulties in Wales are adjusted, for the cheapness and good quality of the north country coal will have been brought to the notice of shipowners who hitherto have always used Welsh coals on their steamers. Ordinary Durham bunker coals are now at 9s. 9d. per ton, and best at 10s. 6d. f.o.b. There is more demand for coking coal than might

have been expected, considering the state of the coke trade. Unscreened coking coals are at 10s. per ton, and coking smalls at 9s. 6d. More activity in the demand for Durham gas coals is reported, and there are good shipments thereof; best gas coals are quoted at 10s. 3d., and seconds at 9s. 9d. f.o.b. The inquiry for steam coals is somewhat quiet, but deliveries are good, and prices firm at 10s. for best and 9s. 9d. for seconds, both f.o.b.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

Pig Iron Warrant Market.

THERE was a distinctly better tendency in the Glasgow pig iron market in the latter end of the past week. Advices from the United States were of a somewhat more cheerful character, and the tone of the market also caught a certain stimulus from an increase in shipments, as well as some reduction in the stocks of Cleveland iron. On the other hand, the Coronation holidays have a restrictive effect on business, and this is specially felt in the paucity of orders from the South. Since last report business has been done in Cleveland warrants from 46s. 3d. to 46s. 6d. cash, 46s. 6d. to 46s. 9d. one month, and 46s. 10d. to 47s. 3d. three months. Sales have also been made of the same class of iron at 46s. 5½d., 46s. 6d., and 46s. 7d. for delivery in eight days, and at 47s. two months.

Scotch Pig Iron Trade.

Inquiries for Scotch pig iron have been on a moderate scale, especially on English account, there being comparatively little prompt business in that direction, no doubt owing to the holidays. There are not wanting indications, however, that a good business may be done with English users in the near future. Local consumers appear to be restricting purchases to present wants. There is a fair export inquiry. Furnaces in blast in Scotland number 83, compared with 85 at this time last year. The better feeling in the warrant market, as well as certain other favourable conditions, some of which are mentioned above, have made prices of Scotch iron steady to firm. Govan and Monkland are quoted f.a.s. at Glasgow:—Nos. 1, 56s.; Nos. 3, 55s.; Carnbroe, No. 1, 60s.; No. 3, 56s.; Clyde, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Gartsherrie and Calder, Nos. 1, 61s.; Nos. 3, 56s.; Summerlee and Langloan, Nos. 1, 63s.; Nos. 3, 58s.; Coltness, No. 1, 82s. 6d.; No. 3, 58s.; Eglinton, at Ardrossan or Troon, No. 1, 56s.; No. 3, 55s.; Glengarnock, at Ardrossan, No. 1, 64s.; No. 3, 59s.; Dalmellington, at Ayr, No. 1, 57s.; No. 3, 55s.; Shotts, at Glasgow or Leith, No. 1, 62s.; No. 3, 57s. 6d.; Carron, at Grangemouth, No. 1, 63s.; No. 3, 58s. per ton. The shipments of Scotch pig iron in the past week were larger than usual, being 4703 tons foreign and 3290 coastwise, the total being thus 7993 tons. Arrivals at Grangemouth of pig iron from Cleveland and district were 5923 tons, compared with 11,692 in the preceding week, a decrease of 5769 tons.

Hematite Ore and Pig Iron.

At one or two Clyde ports there has been a marked decrease in the imports of hematite ore; but taking Glasgow and the Clyde as a whole, the arrivals are only 26,000 tons behind what they were at this time last year. Considering the large supply of hematite pig iron available, and the high cost of ore, it may be regarded as somewhat remarkable that the ore imports do not show a considerably greater decrease. The hematite pig iron market has been weakened still further by the report of increased stocks in the Cumberland district. Cumberland warrants are flat, and nominally 6d. cheaper than they were a week ago. While good deliveries of Scotch hematite are being made to the steel works under old contracts, the current demand is unsatisfactory. Makers are not inclined to relax prices, however, being convinced that the rates are already too low. Business for prompt delivery may be done at these rates—65s. to 66s. per ton—but for future delivery a little more money might be required.

Finished Iron and Steel.

The last reduction in prices of malleable iron brought out such a quantity of orders that makers are able to report better employment than for some time past. They are booking iron at the basis price of £6, less 5 per cent. for crown bars, but for future delivery 10s. per ton extra is required. Foreign business is not easy to obtain at prices that would leave a margin of profit. Some fresh business has been done in steel on home account, but it is small compared with the capacity of the works. Makers have specifications in hand, or in sight, however, that will keep their machinery running for some time. They quote steel angles £6 10s.; ship plates, £6 17s. 6d.; bars, £7 10s., and boiler plates, £7 12s. 6d., less the usual 5 per cent. for delivery in the Clyde district. Export inquiries for steel are encouraging, and there is a fair business in sheets and a variety of other material.

The Shipbuilding Trade.

Several contracts for vessels have come to hand on the Clyde within the last few days, but the accession of new work does not appear, on the whole, to have been large. In some of the yards there has been a scarcity of labour, which has been delaying the progress of construction. The services of the Labour Exchanges have been called for in one or two instances, and a number of young men have by this means been engaged in the Highlands to serve apprenticeship to shipbuilding.

The Coal Trade.

There is a fair volume of business in the coal trade for the season, but heavy outputs have a depressing effect on prices. Endeavours to restrict production are in progress, but it is feared these can meet only with limited success. However, the holiday season is near at hand, and may serve in some measure to relieve the markets.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THERE was a very quiet condition of things on Saturday at Cardiff. Inquiry has been slow for either prompt or forward shipping, but the total clearances have been large, fully confirming the opinion expressed on several occasions in this column—that Welsh coal must be had. It was noticed that shipments for Las Palmas, Port Said, and Genoa were unusually large, as much as 10,000 tons going to one port—Las Palmas; 9000 tons went to Genoa, 5000 to Aden, and 4000 to Naples. In all, the shipments on Friday were close upon 100,000 tons from Cardiff. It was stated on 'Change on Saturday that most shippers had completed arrangements for loading until the middle of next week, covering the Coronation holidays. Smalls were reported scarce, and the tendency was for improved quotations. As it was, cargo smalls were quoted at 9s. to 9s. 3d., while best bunker smalls in some cases figured at 11s. 3d.

Latest Quotations.

On Monday at Cardiff the following quotations ruled. Business limited, colliery owners quoting firmly for the principal large and small coals; buyers expected developments affecting colliers and seamen, and this caused operations to be very restricted. Latest:—Best large, 18s. 3d. to 18s. 9d.; best seconds, 16s. 9d. to 17s. 6d.; ordinaries, 16s. to 16s. 6d.; best drys, 16s. to 16s. 9d.; ordinary drys, 14s. 9d. to 15s. 6d.; best washed nuts, 14s. 6d. to 15s.; seconds, 13s. 6d. to 14s.; best washed peas, 12s. 6d. to 13s. 6d.; seconds, 11s. to 12s.; best bunker smalls, 10s. 9d. to 11s. 3d.; best ordinaries, 10s. 3d. to 10s. 6d.; cargo smalls, 9s. to 9s. 3d.; inferior, 8s. to 8s. 6d.; best Monmouthshire black vein, 15s. 9d. to 16s. 3d.; ordinary Western Valleys, 15s. 3d. to 15s. 6d.; best Eastern, 14s. 3d. to 14s. 9d.; seconds, 14s. to 14s. 3d. Bituminous coal:—Very best households, 17s. to 18s.; best ordinaries, 14s. 6d. to 15s. 6d.; No. 3 Rhondda, 17s. to 17s. 6d.; brush, 13s. 3d. to 13s. 9d.; smalls, 10s. 6d. to 10s. 9d.; No. 2 Rhondda, 12s. to 12s. 3d.; through, 10s. 3d. to 10s. 6d.; smalls, 8s. to 8s. 6d. Patent fuel, 16s. 9d. to 17s. 6d. Coke: Special foundry, 24s. to 25s.; foundry, 18s. to 20s. 6d.; furnace, 16s. to 17s. Pitwood, 18s. to 18s. 6d.

Newport, Mon., Coals.

A very slow condition prevailed on Monday; tonnage short and supplies easy; sellers maintaining forward prices and holding over inquiries. Latest:—Very best black vein, 15s. 6d. to 16s.; Western Valleys, 15s. to 15s. 3d.; Eastern, 14s. to 14s. 3d.; other sorts, 13s. 6d. to 13s. 9d.; best smalls, 8s. 6d. to 8s. 9d.; seconds, 8s. to 8s. 6d.; inferiors, 7s. 9d. to 8s. Bituminous: Best household coal, 15s. 6d. to 16s. 6d.; seconds, 14s. to 15s. Patent fuel, 16s. to 17s. Coke: Foundry, 18s. to 20s.; furnace, 16s. to 17s. Pitwood, 18s. to 18s. 6d.

Swansea Coals.

There was a small attendance when the offices opened, and very little business was done during the day. Prices generally were maintained. Latest quotations: Best malting, 21s. to 23s. net; seconds, 17s. 6d. to 19s. 6d. net; big vein, 15s. 6d. to 17s. 6d., less 2½; red vein, 11s. 6d. to 13s. 6d., less 2½; machine-made cobbles, 20s. 6d. to 22s. 6d. net; Paris nuts, 22s. to 23s. 6d. net; French nuts, 21s. to 23s. 6d. net; German nuts, 21s. 6d. to 23s. net; beans, 19s. 6d. to 21s. 6d. net; machine-made large peas, 10s. 6d. to 11s. 6d. net; fine peas, 9s. 6d. to 10s. net; rubbly culm, 7s. 6d. to 7s. 9d., less 2½; duff, 3s. 3d. to 3s. 9d. net. Steam coal: Best, 18s. 3d. to 19s.; seconds, 14s. 3d. to 15s. 6d.; bunkers, 10s. 6d. to 11s. 6d.; small, 7s. 6d. to 8s. 6d., all less 2½. Bituminous: No. 3 Rhondda, 17s. 6d. to 18s. 6d.; through, 15s. 6d. to 16s.; small, 10s. 9d. to 11s. 6d., all less 2½. Patent fuel, 14s. 6d. to 15s., less 2½.

French State Railway Orders.

It was stated on 'Change, Cardiff, that the French State Railways had placed orders with German exporters for about 400,000 tons of small steam coal to be delivered at Bordeaux at a price equal to about 6s. per ton f.o.b. A later announcement is that on Saturday the Main Colliery was notified by the Board of its acceptance of considerably more than half of its requirements, the contract extending over twelve months. No definite information is obtainable as regards the White Star Company's contract, but it is said that the Lewis Merthyr Colliery Company and Messrs. Mann, George and Co. have been allotted portions of the contract, and that the White Star Company has arranged for supplies over twelve months.

The Strike.

No final announcement has been made with respect to the resumption of work. The continuance of the strike is considered to depend upon the strike fund, and that with its discontinuance the strike must end. A little time is now being charitably allowed, but in the best interests of the colliers the sooner steps are taken for the re-opening of the collieries the better.

Tin-plate.

Totals again were decisive proof that the temporary slackness in the trade has now disappeared, and with the assurance of a good understanding between the employers and the men, a satisfactory state of trade is certain. Makers' quotations are unchanged, ordinary Bessemer cokes being quoted at 13s. 9d. to 13s. 10½d. Tin-platers and sheet men have agreed to suspend operations from 10 p.m. on Wednesday, 21st June, and resume operations at 6 a.m., June 23rd.

Appointment for a Swansea Engineer.

It is announced that Mr. Oldham, chief assistant-engineer to Swansea Harbour Trust, has received the appointment of chief constructive engineer to the great new dock works which Messrs. C. H. Walker and Co. are to construct at Buenos Aires. These are estimated to cost six millions, and will take about ten years to complete.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

IRON and steel has, generally, continued in a favourable condition, but some branches show dulness; in bars, for instance, a slightly decreasing tendency has been noticeable. The syndicate questions are also troubling the iron market. The trade in iron ore is less favourable than could be desired; the Siegerland mines have been compelled to restrict their output, but stocks are rising, nevertheless. Prices for the third quarter are going to be the same as before, viz., M. 11.60 for raw, and M. 16.50 p.t. for roasted ditto. Prospects for the Pig Iron Covention are less favourable than before. Pig iron generally is firm, but quiet; the Siegerland blast furnace works have resolved not to sell below the minimum quotations recently fixed, which are M. 65 p.t. for spiegeleisen, against M. 63 to M. 65 previously quoted; M. 60 p.t. for forge pig, as compared with M. 58 to M. 59 p.t.; basic, M. 61 p.t., as compared with M. 59 to M. 60 p.t., all free Siegen. Sales of the Steel Convention are fairly good, in spite of a somewhat slow export trade. A fair demand is coming in for railway material, although the requirements of the State Railways are disappointingly low. Sectional iron remains animated. The demand for raw bars was lower in May than previously, production also shows a falling off and prices are decreasing slowly; they range between M. 97 to M. 103 p.t. for Martin quality, and M. 112 to M. 115 p.t. for best sorts. The Convention for prices for wire, wire nails, and wire articles will end on June 30th; in consequence of this, and also in order to meet the foreign competition, the price for wire rods in basic has been reduced M. 7.50 p.t. for the third quarter.

Steel Convention.

Sales of the Steel Convention in May of the present year are officially stated to have been 532,356 t., as compared with 440,416 t. in April of the present year, and as compared with 387,594 t in May, 1910. Of the above-named quantity 130,177 t. were semi-finished steel, as compared with 124,927 t. in April, and as compared with 107,197 t. in May last year; railway material, 200,704 t., as compared with 137,352 t. in April of the present year, and as compared with 134,893 t. in May last year; sectional iron, 201,475 t., as compared with 178,137 t. in April of the present year, and as compared with 145,504 t. in May last year.

Production of Pig Iron.

According to official accounts given by the Union of German Iron and Steel Masters, the output of pig iron in Germany, including Luxemburg, for May of the present year was 1,312,255 t., as compared with 1,285,395 t. in April of the present year, and as compared with 1,261,735 t. in May, 1910. The output of different sorts of pig iron was as follows:—Foundry pig, 263,749 t., as compared with 244,886 t. in May, 1910; Bessemer, 24,692 t., as compared with 40,689 t.; basic, 132,356 t., as compared with 119,843 t.; forge pig, 39,227 t., as compared with 57,389 t. in May, 1910. During the period from January to May 31st of the present year the production of pig iron was 6,419,642 t., as compared with 5,982,961 t. in the same period last year.

Coal in Germany.

Engine classes of fuel meet with good request at stiff quotations, both in Rheinland-Westphalia and in Silesia.

Austria-Hungary.

In all the principal trades a pretty lively occupation was reported last week, more orders having come in lately; still, a want of animation and of enterprising spirit is complained of, and the tendency of prices is less firm than could be desired. Engine coal is in good demand and firm in price; house coal remains languid, as before.

The Belgian Iron Market.

A small export has been done in semi-finished steel for some weeks past, and prices are cut very fine; the Syndicate of the Belgian Steel Works has, accordingly, reduced rates for billets from 81f. p.t. to 79f. p.t. The figures for steel export for the first quarter of the present year show a considerable rise as compared with the same quarter in 1910, *i.e.*, 13,300 t. to 32,150 t. The increase in value amounts to nearly 1½ million francs. Scrap iron, and especially old rails, are in slow demand, and are offered at 5f. p.t. less than officially quoted. A weakening tendency is felt in the prices for bars, especially as regards export. In the first quarter of the present year the export of bars was 128,500 t., as compared with 115,100 t. in 1910. The increase accordingly is 13,400 t. The tendency in finished iron is fairly stiff, girders sell freely, both on home and on foreign account; increase for the first quarter was slight. Quotations have not changed. At the rail mills work is plentiful; extensive foreign orders have come in, but for local requirements several thousand tons have also been ordered, and the laying of new railroads in the Belgian Congo will help to increase employment. Export prices remain £5 2s. 6d. and £5 7s. p.t., inland prices being 150f. to 155f. p.t. The export of rails in the first quarter of present year was 38,200 t., as compared with 36,400 t. in the same period last year. A good export is done in plates, and here, also, a rise can be noticed as compared with last year, 41,000 t. having been exported, as compared with 28,600 t. Sheets stand on £6 5s. p.t., and heavy plates on £5 15s. p.t.: plates in basic fetch £5 13s. p.t., while inland quotations are 145f. to 150f. p.t. Engine coal is in good demand at stiff prices. In house coal little is done.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, June 14th.

THE general tenor of trade in the iron and steel industry has somewhat improved within a week, although elements of unrest have not altogether disappeared. A great many buyers are still delaying ordering for future delivery, contenting themselves with restricted purchasing to cover immediate necessities until conditions have settled themselves more fully. The curtailment in the production in crude steel has permitted the absorption of most of the surplus stock, and to this extent the market is better. Forging billets have been reduced by recent cuts from 28 dols. to 26 dols., and the new official prices promised to be upheld without friction. Reductions have been made in merchant steel in jobbing centres to harmonise prices with wholesale prices. A few railroad companies have placed orders during the week, and rail makers think a few more companies will follow suit. The car companies, which have been operating to about 55 per cent. of capacity, are in correspondence with railroad companies which is believed to result in a few days to a 60 per cent. output. Throughout the west the agricultural implement manufacturers have been buying quite heavily since the cut of 3 dols. per ton was made by the Republic Iron and Steel Company. The reduction in sheets of 3 dols. to 4 dols. per ton has also helped to develop orders both west and east, and the sheet mills for a few weeks at least will have a little more work. The tin-plate mills have orders on their books which will keep them busy for about three months and about 70 per cent. of their maximum capacity. The structural and plate mills are running to about one-half of their capacity, and the present prospect for business will keep them up to that limit, possibly through the summer. Conditions are ripening for a heavy demand for pig iron according to the views of the furnace interest, but this is a view that is not very well supported by actual market facts. Export orders for the past week for rails reach pretty nearly 30,000 tons. There is much railroad projection on the western hemisphere, especially in Brazil and Argentine, and railmakers are hopeful of doing a large business with the twenty or more Republics to the southward. The agitation concerning the methods of the United States Steel Corporation still continue, and after the larger questions have been thrashed out the matter of labour conditions will be taken up, but this phase of this investigation may not be reached until autumn. The copper market is in a more settled condition, as a result of a comparison of consumption in Europe and the United States with the figures of production made public by the Copper Producers' Association. Should the proposed electrification of the German and French railways be resolved upon, the copper producers see an element of strength to the market which will be most welcome. Tin temporarily advanced in price a few days ago for reasons which do not appear on the surface. This has had the effect of withholding a few buyers. Arrivals so far this month, 808 tons. Total amount afloat, 853 tons.

PERSONAL.—We are informed that the name of the Patent Indented Steel Bar Company, Limited, has been altered to the Indented Bar and Concrete Engineering Company, Limited. The business of the firm will not be altered, but will be carried on under the new name at the same address, Queen Anne's-chambers, Westminster. Telegrams: Patinbar, London. Telephone: 1642 Victoria.

WE hear that the German Postal authorities are about to extend considerably the use of electrical motor vehicles in connection with the collection and delivery of the mails. For the collection of the letters from the street letter-boxes an electric carrier tricycle has been adopted, and the first of these have been put to work in connection with one of the post-offices in Charlottenberg, and one in North Berlin. The machines, which have been built by the Berliner Elektromobilfabrik, of Berlin, are capable of running a distance of about 44 miles on one charge of the battery, at speeds ranging from 10 to 12 miles per hour, and of carrying a load of 5 cwt. The experiments which have so far been made show that a considerable saving in the time occupied in collecting the mails is effected by means of the new machines.

DUMP car bodies were altered so as to be readily lifted from the trucks by derricks and dumped as skips, in the excavation of a part of the North Shore channel of the Sanitary District of Chicago. This was done, states the *Engineering Record*, to meet a condition where the settlement and flowing of the soft clay on the dump made it difficult to maintain dumping tracks near its edge. Travelling derricks, standing on the solid fill and advancing with it, lifted the car bodies by means of a gear of chains, with a spreader bar, engaging hook-eyes at the ends and one side. The dumping door on that side was permanently fastened in the closed position, while the other retained its swinging arms. The hinged door was held by a line in the chain gear so that it swung open in the usual way when a trip line at the opposite closed side tipped the body toward it to dump. The car bodies were swung out beyond the solid fill, dumped and returned to their trucks.

CATALOGUES.

BOULTON AND PAUL, Limited, Norwich.—This is a catalogue having reference to steel-framed buildings.

H. D. MORGAN AND CO., 12, Jordan-street, Liverpool.—From this firm we have received two circulars illustrating Morgan's patented railway carriage ventilator.

THE SHEPPEE MOTOR COMPANY, York.—This is an admirably got up catalogue dealing with the Sheppee "Overseas Special" light steam commercial vehicles for goods and passengers.

THE UNION STANDARD MACHINE COMPANY, 165, Queen Victoria-street, S.W.—A circular from this firm has reference to "The Planos" portable hand-planing, slotting, gear and keyway cutting machine.

THE MUNICIPAL ENGINEERING AND CONTRACTING COMPANY, Chicago, U.S.A.—The Chicago improved cube concrete mixer is illustrated and described in a well-got-up catalogue sent to us by this firm.

THE GANDY BELT MANUFACTURING COMPANY, Limited, Seacombe, Cheshire.—This catalogue describes driving and conveyor belts, and enters into many interesting considerations relating to the use of belts for these purposes.

FYFE, WILSON AND CO., 145, Bath-street, Glasgow.—List 112 has reached us. It deals with the "Kelvin" petrol and paraffin-driven electric generating sets for use in the lighting of country houses, hotels, shooting lodges, coast houses, &c.

J. SAGAR AND CO., Limited, Canal Works, Halifax.—This is a little pamphlet dealing with Sagar's patented chain cutter and hollow chisel mortising and boring machine. It is a well illustrated publication, and describes the principle and advantages of this machine in a clear and concise manner.

NICHOLS BROTHERS, Oakwellgate, Gateshead-on-Tyne.—Pumping machinery for marine, electric light, and general power installations is dealt with in a well illustrated catalogue received from this firm. Pumps suitable for all classes of service are described, and other information of interest to buyers is given.

THE AERONAUTICAL SYNDICATE, Limited, Collindale-avenue, West Hendon, N.W.—This is a little book which sets forth the work undertaken by the Aeronautical Syndicate, which consists of designing and building aeroplanes, propellers, and other accessories, and improving unsuccessful machines. A school of flying is also carried on by the syndicate.

THE BOWESFIELD STEEL COMPANY, Bowesfield Steel Works, Stockton-on-Tees.—A neat little pocket-book sent to us by this company deals with steel sheets, black and galvanised, and plain and corrugated. It also makes reference to galvanised roofing fittings, including gutters and spouts, pipes, and so forth. At the end of the book there are some useful tables.

THE BRITISH INSULATED AND HELSBY CABLES, Limited.—This catalogue about the Prescot welder contains much interesting information, and the principle of operation is clearly described. Welding machines suitable for various classes of service are illustrated, and each illustration is accompanied by a brief description. Prices are given throughout, also dimensions and weights.

THE LINOLITE COMPANY, 25, Victoria-street, Westminster, S.W.—"Electric Lighting" is the title of a neat little pamphlet to hand from this firm. It deals with the firm's Tubolite reflectors, which are claimed to economise the light, and to direct it where it is required. We have also received a circular letter from which we note that the firm is now supplying "Tubolite" lamps for pressures of 100 and 125 volts.

WM. GEIPEL AND CO., Vulcan Works, 72A, St. Thomas-street, S.E.—A new price list has reached us. It has reference to Kerion carbons for arc lamps, cinematographs, projectors and welding. The special properties of these carbons are clearly set forth, and prices, code words, and other useful information is given. We have also received a well got-up pamphlet dealing with graphitic carbon brushes for dynamos and motors.

HEENAN AND FROUDE, Limited, 4, Chapel-walks, Manchester.—This is a catalogue which illustrates and describes the Froude patented water dynamometer for measuring the power developed by engines and motors. From a notice in the first part of this catalogue it appears that during the last few months this firm has modified the "Froude" water dynamometer and has evolved a machine which is simple, compact, very efficient, and less costly to produce than the original dynamometer.

JOHN RUSSELL AND CO., Limited, Alma Tube Works, Walsall.—This is an extensive catalogue of tubes and fittings of all kinds, for gas, steam, water, &c., and general engineering purposes. It contains much useful information on steam-pipe work, flanges, bends and outlets, special welding work, casing tubes and oil line equipments. It also gives hydraulic data, pipe-work tables, and standard screwing sizes. The catalogue is one which should prove of considerable value to general engineers.

THE INDIA-RUBBER, GUTTA-PERCHA AND TELEGRAPH WORKS COMPANY, Limited, Silvertown, London, E.—"Galvanic Batteries" is the title of a catalogue sent to us by this firm. It deals with primary batteries of various kinds, and suitable for all classes of service. Prices and other particulars are given of Leclanché cells, medical batteries, Bunsen cells, Minotti cells, and Daniel cells. From the same firm we have also received a catalogue having reference to gutta-percha, india-rubber, silk and cotton covered wires, jointing, tools, and various wiring materials.

BRITISH STEAM SPECIALTIES, Limited, 80, Turnmill-street, London.—This is an extensive and well-bound book. It is divided into four sections, which deal with the following goods:—Section I.: Reducing valves, pressure regulators, steam and grease separators, back pressure and exhaust relief valves, steam traps, pump governors, exhaust heads, heaters and calorifiers, duplex pumps, centrifugal and semi-rotary pumps. Section II.: Iron body and gun-metal globe and gate valves, cast iron and gun-metal plug and gland cocks, water and steam pressure gauges, drain and test cocks, safety and relief valves, injectors, thermometers, lubricators, fire service fittings, gun-metal pipe fittings, radiator fittings, including all classes of valves, air valves, floor plates, towel rails, plumbers' brasswork, including screw-down cocks, ball valves, gas fittings, asbestos packing, &c. Section III.: Wrought iron tubes and fittings, malleable pipe fittings, soft cast iron pipe fittings, flanged pipe and fittings, pipe brackets and rollers, hangers and stands, joint rings and pipe joint compound, pipe cutters, screwing machines, stocks and dies, pipe wrenches and tongs, vices, pipe bending machines, forges, and all classes of fittings and tools in connection with piping installations. Section IV.: Radiators and radiator accessories, including ventilator quadrants, floor inlet grates, high legs and pedestals, boilers for heating apparatus for steam and water constructed of cast and wrought iron, automatic boiler feeders, tanks and cylinders, fans of every description, roof ventilators, cast iron and stamped steel louvre ventilators, cast iron grates and frames, air bricks.

PRESENTATION TO THE INSTITUTION OF GAS ENGINEERS.—In connection with the annual conference of the Institution of Gas Engineers, recently held at Glasgow, an exceedingly pleasing incident at the luncheon in the City Chambers, over which the Lord Provost, the Hon. A. McInnes Shaw, presided, was the presentation of a beautifully designed and mounted president's hammer and striking board sent by the German Association of Gas and Water Engineers as a memento of their visit to British gas engineers last year. The gift was received with great appreciation, and was suitably acknowledged.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

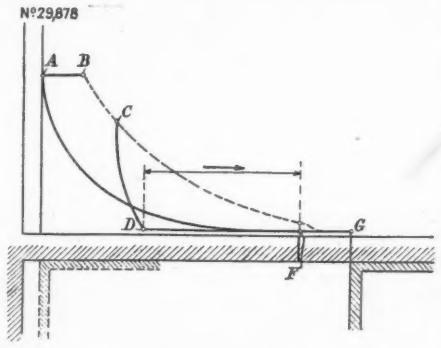
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of the Patent.

INTERNAL COMBUSTION ENGINES.

29,878. December 23rd, 1910.—IMPROVEMENTS RELATING TO THE STARTING OF INTERNAL COMBUSTION ENGINES, Stanley Gordon Sinclair Dicker, of 37, Furnival-street, Holborn, London.

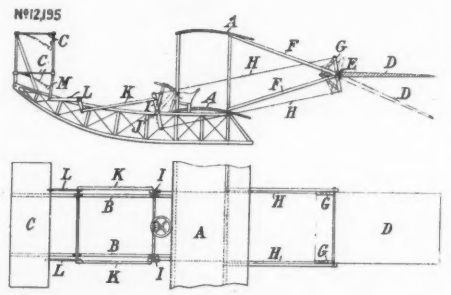
In starting a two-stroke motor by means of compressed air, the temperature in the cylinder at the end of the expansion of the compressed air is very low. During the compression, therefore, the attainment of the ignition temperature of the fuel mixture is rendered doubtful, particularly if the scavenging is not sufficient or if the motor is working without scavenging, so that a reliable ignition and starting of the motor are rendered impossible. The present invention has for its object to remove this drawback. Assuming the motor receives a compressed air charge from point A to point B, and expansion commences from point B and is interrupted at point C, for instance, by opening the valve, piston slide, or the like, equalisation of pressure will be established between the interior and exterior of the cylinder, this pressure equalisation taking place, for example, at point D. This will take place sooner or later, according to the extent of the valve opening. Suction then begins from point D by the piston travelling from this point to point F. The suction may take place through a special valve or through the valve serving for establishing the pressure equalisation. From point F to point G the piston travels over the exhaust ports, and on the return stroke of the piston compression commences at point F and reaches its maximum at point A. The object of this method is to control in a determined manner the temperature values. At the end of the stroke the cylinder contains a quantity of air of considerably higher temperature than would be the case in the event of an uninterrupted expansion.—*May 31st*, 1911.



AERONAUTICS.

12,195. May 18th, 1910.—IMPROVEMENTS IN FLYING MACHINES, Hampden Sanders and Haydy Arnold Sanders, of 23, Blenheim Park-road, Crydon, Surrey.

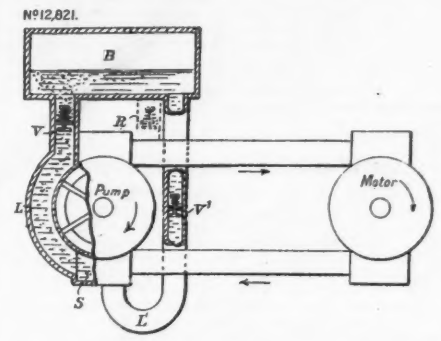
This invention relates to flying machines having main or supporting planes and has for its object to provide improved means for maintaining such machines in the horizontal position when flying. A A indicate the usual supporting planes and B the trussed framing carrying the elevating planes C C at the front. D is a horizontal plane arranged in accordance with the invention, the plane being pivoted at its forward end at E upon brackets or supports F F at the rear of the machine. To this plane are attached arms G G, which arms are each in turn connected by wires H H to the ends of double-armed levers I I attached to the steering handle by the shaft J. These double-armed levers I I are in turn connected by rods K K, bell-crank levers L L and rods M to the elevating planes C C. With this arrangement it will be understood that should the front part of the machine tend to fall below the horizontal, the rear hinged plane D will tend to follow the movement of the machine and so expose its upper surface to extra resistance from the atmosphere, so that the air pressure will tend to force it downwards towards the position indicated by the dotted lines, and at the same time tend to move the planes C C also as indicated by the dotted lines, to raise the front of the machine again, whereupon the air acting on the underside of the plane D will restore the latter to its normal position, and also the front elevating planes C C. By operating the steering wheel the aviator may alter the line of flight independently of the automatic action by pushing or pulling the steering wheel away from or towards himself.—*May 31st*, 1911.



TRANSMISSION OF POWER.

12,821. May 26th, 1910.—IMPROVEMENTS IN APPARATUS FOR THE TRANSMISSION OF MOTIVE POWER BY MEANS OF LIQUID PRESSURE, *The Internationale Rotations-Maschinen-Gesellschaft Mit Beschrankter Haftung, of* 6-7, *Schiffbauerdamm, Berlin.*

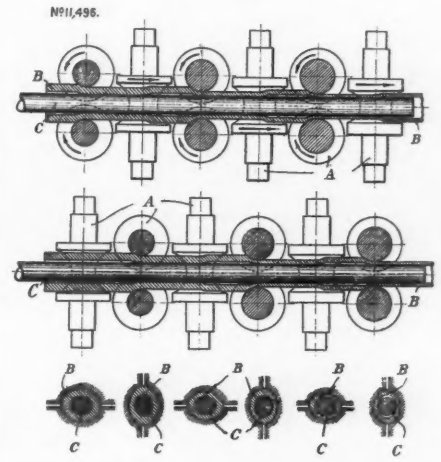
This invention relates to an apparatus for relieving the propelling medium of liquid pressure transmission gear of air. The suction chamber S of the pump P is connected by two conduits L L^1 containing check valves V V^1, with a liquid receptacle B situated at a higher level. The two conduits L L^1 emanate from points placed at different levels, one of them preferably from the highest point of the suction space. The space of the liquid pressure transmission gear, which in normal working receives the high-pressure propelling mechanism, is connected with the receptacle B by a conduit R provided with a check valve, in order that a compensating flow of liquid may also take place into this space, if it acts temporarily as the suction chamber. Experience has shown that in the hydraulic transmission of power disagreeable interruptions of working arise from the access of air to the spaces which receive the propelling medium (usually oil), such access taking place through leaky portions of the receptacles and through the axle bearings, which cannot be kept perfectly impervious. The air which has penetrated into the machine mixes with the propelling medium in the form of bubbles, and causes the formation of froth. The object of the invention is to overcome these difficulties.—*May 31st*, 1911.



MACHINE TOOLS AND SHOP APPLIANCES.

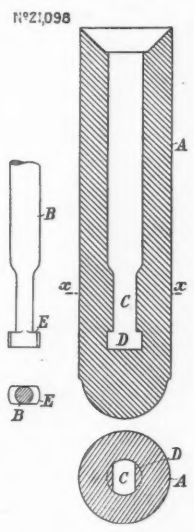
11,496. May 14th, 1909.—ROLLING MILL FOR PRODUCING TUBES, *Mathias Peters, of* 21, *Hildenerstrasse, Benrath, near Düsseldorf, Germany, and Karl Gruber, Director of Hospitalstrasse, Benrath, Germany.*

By using passes of the same eccentricity for all pairs of rolls A the friction between the mandril C and the work piece B is reduced as much as possible as the tube, of elliptical section, only comes into contact with the circumference of the mandril at two places, and therefore easily slides over the same, so that the power for operating the mill is decreased and the great, injurious strain upon the work piece is avoided, and thus the tubes produced are of a much superior quality, especially as regards reduction in thickness of wall. The relative speed of the mandril to the work changes from one pair of rolls to the other, through which the work passes; that is to say, the mandril adopts a speed which is the most favourable to the tube which is being rolled.—*May 31st*, 1911.



21,098. September 10th, 1910.—IMPROVED STOPPER FOR FOUNDRY LADLES, William James Caulfield, of Lochryan, Calder-road, Mossend, Lanarkshire.

The stopper comprises a block A formed in one piece of fire-clay or like material, which embraces the end of the usual metal ladle-rod B and extends upwards to form a protective sleeve for the

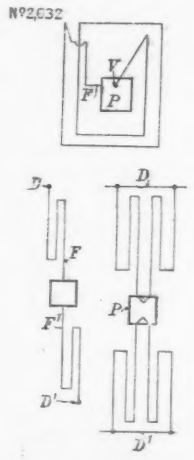


portion of the rod which is immersed in molten metal. A slot or recess C, enlarged at its inner end, as at D, is formed in the block A to accommodate the end of the ladle-rod B. The ladle-rod end is formed with a T-shaped head E, and is secured to the fire-clay block A by rotating the rod B through an angle of 90 deg., so that the T-shaped head E engages with the enlarged end D of the recess in the block A. The space between the fire-clay block A and the rod B is packed with sand or other suitable material. The portion of the metal rod B extending above the fire-clay block A may be protected in the usual way by fire-clay or like sleeve bricks. A stopper constructed as above described possesses obvious advantages over that type of stopper in which the sleeve is jointed so as to provide a short stopper end which is secured to the rod by pin and cotter connections or by means of a T-piece or flange on the ladle-rod, which T-piece or flange is slid or rotated into a recess in the stopper.—*May 31st*, 1911.

TELEGRAPHS AND TELEPHONES.

2632. February 1st, 1911.—IMPROVEMENTS IN THE ANTENNÆ OF WIRELESS TELEGRAPHY AND TELEPHONY. *Ettore Bellini and Alessandro Tosi, both of 21, rue de Louvre, Paris, France.*

The object of this invention is to allow the wave length to be varied to many hundreds of metres, without employing any self-induction coil and thus preventing obstruction in the interior of the station. The process consists in connecting to the transmitter or receiver one or more equal conductors, emerging from the station and only reaching the base of the antenna after having made, outside the station, one or more windings of suitable length, to permit of attaining the desired wave length. The upper engraving represents the process applied to an antenna with uni-

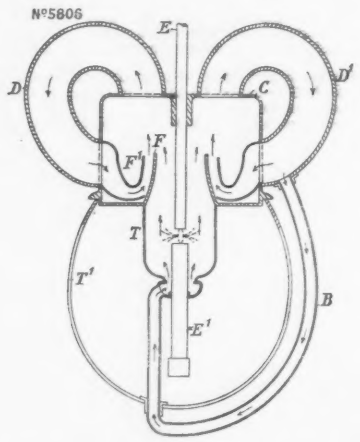


form radiation; V represents the projection on the horizontal plane. The conductor F emerging from the interior of the station P makes some windings before attaining the base of the antenna V. The left-hand lower engraving shows the process applied to a dirigible aerial consisting of a couple of antennæ symmetrical with regard to the vertical, of which D and D^1 represent the projections on the horizontal plane. The conductors F and F^1 on emerging from the station make two windings before attaining the bases of the antennæ D and D^1. The right-hand lower engraving shows a similar example to the preceding, but instead of having a single conductor for each antenna, two conductors in parallel have been used.—*May 31st*, 1911.

LIGHTING AND HEATING.

5806. March 8th, 1911.—IMPROVEMENTS IN AND RELATING TO ELECTRIC ARC LAMPS, John Owen Girdlestone, of 37, Warwick-road, Ealing, and Carl Frederik Grimur Thorkelin, of 30, Marriott-road, Tollington Park.

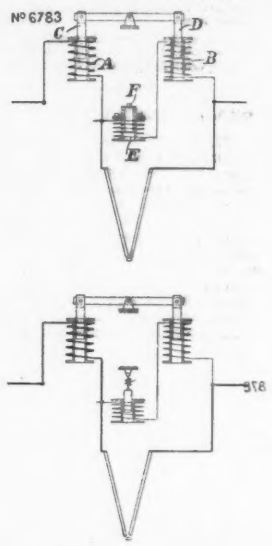
This invention relates to arc lamps of the enclosed flame type, in which it is important to arrange for a circulation of the gases in such a manner that the smoke and fumes do not become deposited on the transparent part of the enclosure in any objectionable



degree. E and E^1 are the electrodes. C is the chamber into which the hot gases pass from the arc. D and D^1 are ducts connecting the upper with the lower part of the chamber. F is the funnel or opening through which the hot gases pass into the chamber. F^1 is the funnel which surrounds F^1 and to which the main flow of the cooled gases is led from the ducts D and D^1. B is the equalising tube or by-pass which connects the upper part of the enclosure with the lower part below the arc. T and T^1 are the transparent parts of the enclosure. The arrows indicate the paths which the gases follow when the lamp is burning.—*May 31st*, 1911.

6783. March 18th, 1911.—IMPROVEMENTS IN ALTERNATING-CURRENT ARC LAMPS, *Körting and Mathiesen, Aktiengesellschaft, Leutzsch, Leipzig, Germany.*

In alternating-current arc lamps in which the control of the lamp is effected by a shunt-wound solenoid acting on an iron core or an electromagnet acting on an armature, it has been found that the feed control is effected by the movement of the core or armature in or towards the solenoid or electromagnet which weakens the magnetic attraction. It has been found that this defect can be remedied by introducing into the shunt circuit in advance of the shunt-wound solenoid a choking or impedance coil fitted with either fixed or movable iron core, through which coil, therefore, the same current flows as through the shunt-wound solenoid. The upper engraving shows the arrangement on a differentially wound lamp with carbons side by side. The

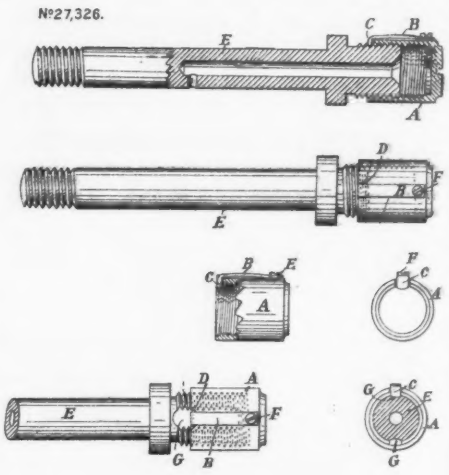


mechanism may consist of the series-wound solenoid A, and the shunt-wound solenoid B, into which the iron cores C and D project and swing on a beam round centre. In the circuit in front of the shunt-wound solenoid B is the choking coil E; this is fitted with iron core F, adjustable as to its projection into the coil. Considerably increased magnetic effect of coil B can be attained if core F can be suspended on a spring as shown in the lower engraving.—*May 31st*, 1911.

MISCELLANEOUS.

27,326. November 24th, 1910.—IMPROVEMENTS IN OR CONNECTED WITH PRESSURE FEED GREASE CUPS, Charles Phipson Showell, of Stirchley Brassfoundry, Stirchley, Birmingham.

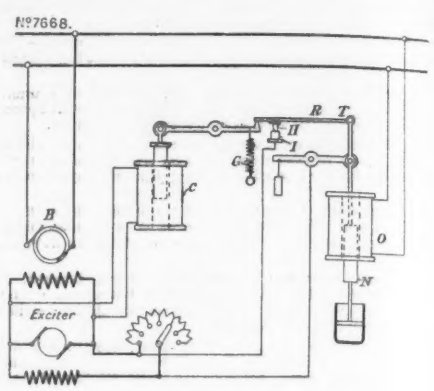
This invention relates to pressure feed grease cups primarily intended for application to the "shackle pin" by which the spring of a motor car is assembled in position. It is also applicable, however, to grease cups used for other purposes. Upon the exterior of the cup A a spring claw or scraper B is provided, whose free end C is carried to a point below the cup, or it may pass through a hole or gap D in the side of the cup, in each case impinging upon



or engaging with the screw threads upon the shackle pin E, so that the screw thread is cleared or cleaned when the cup A is screwed on. The claw may be fixed to the cup by any convenient means, as by a set screw F. The claw may be further utilised as a snap check to the feed by providing grooves G in the screw threads of the pin E for a given distance upwards, say to within two or three threads at the top. Pins of this kind are usually exposed to mud and rust, by which the freedom of screwing and unscrewing of the cap is impeded, and the object of this invention is to overcome this objection by providing means for scraping the screw thread each time the cap is used.—*May 31st*, 1911.

7668. March 27th, 1911.—IMPROVEMENTS IN ELECTRIC VOLTAGE REGULATORS, *the Allgemeine-Elektricität's Gesellschaft, of Friedrich Karl Ufer 2-4, Berlin, Germany.*

This invention relates to the regulation of the voltage of dynamo-electric machines, and is more especially applicable to machines of the Tirrill type. When the potential of the generator B assumes less than its normal value on account of increased load, then the core N sinks down, and with it the end of the lever R, carried movably at the point T. In this way the contact of the contacts H and I, in spite of the left end of the lever R being raised by the tractive force of the coil C, is retained, and for so long until the exciter potential, increased by the short-circuit of the resistance K, again establishes the normal generator potential. At this moment the core N, in spite of its somewhat altered position of height, is again in equilibrium, and the opening and closing of the contact H and I is now affected at a somewhat higher position of the knife—that is to say, at a higher tension of the spring G. A special advantage is that each of the two relays C and O can be arranged in such mechanical connection with the movable contact H that a reciprocal action of the movements of the two relays does not take place, so that two relays can come into acton upon the movable contact independently of each other. By this independence an extremely fine and exact regulation can be obtained. Instead of for periodic short-circuiting of a resistance,

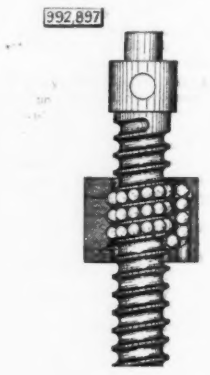


the potential regulator can serve also for the periodic insertion of short-circuiting of exciter windings.—*May 31st*, 1911.

SELECTED AMERICAN PATENTS.

(From the United States Patent-office Official Gazette.)

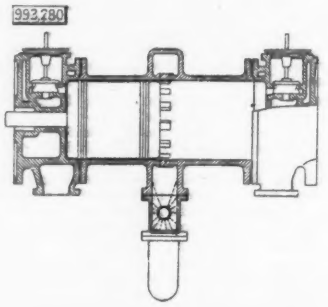
992,897. BALL-BEARING SCREW, *W. S. Nichols, Newark, and J. H. George, Harrison, N.J., assignors of one-third to said W. S. Nichols, one-third to said J. H. George, and one-third to H. J Skipp, Newark, N.J.—Filed June 22nd*, 1910.



This invention claims to give the world a "new mechanical element." The construction is very obvious. The balls are returned through a side passage. There are two very long claims.

993,280. CONDENSING ENGINE, *J. Stumpf, Berlin, Germany.—Filed February 15th*, 1910.

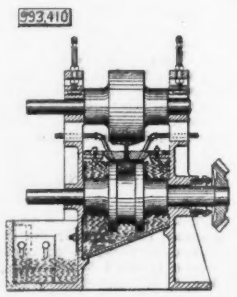
This patent is for the combination with a cylinder having an inlet port at one end, exhaust ports at some distance from that



end, and an external circumferential chamber covering said exhaust ports, of a piston controlling said exhaust ports as it reciprocates, and means for cooling said chamber. There are two claims.

993,410. TREATING STEEL RAILROAD RAILS AND OTHER LIKE BARS, *J. C. Russell, Pittsburg, Pa.—Filed March 12th*, 1910.

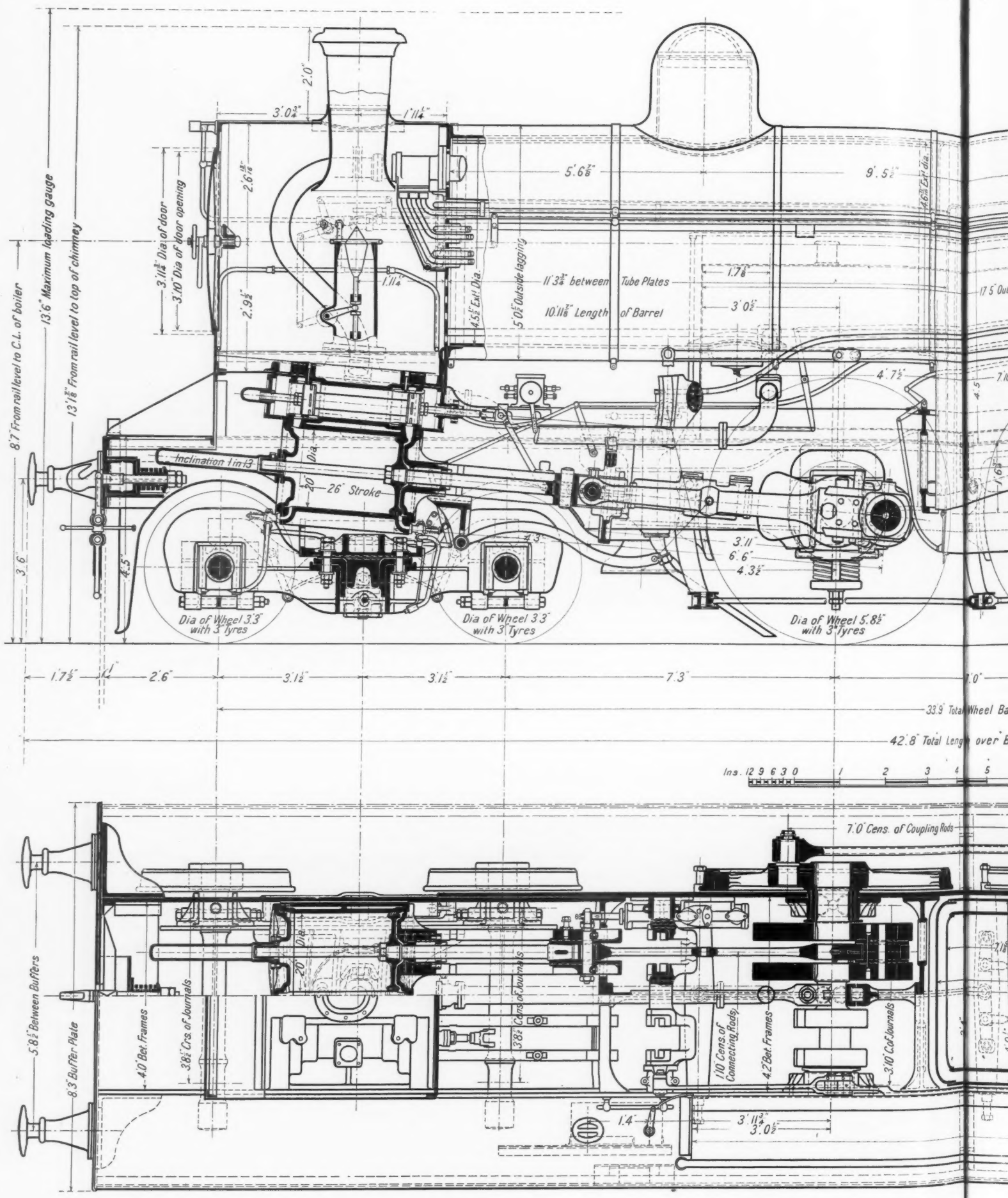
This patent is for a process of treating rails, which consists in passing the hot finished rail through a cooling medium bath of oil



extending around the head only and then passing the rails through a cooling medium bath wherein water extends around the head. There are sixteen claims.

LONDON AND NORTH-WESTERN RAILWAY—SUPER

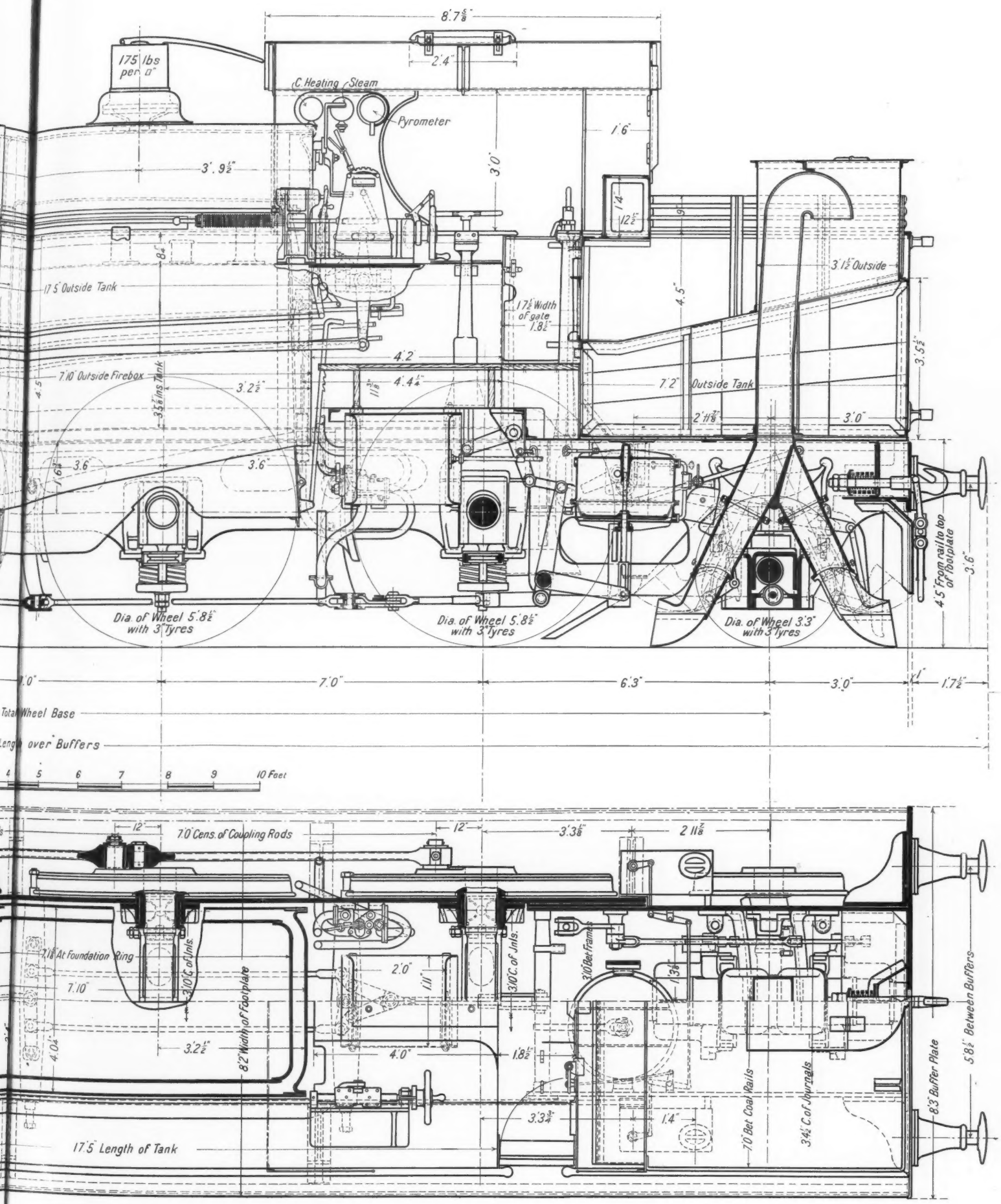
C. J. BOWEN COOKE, M. [illegible], C.E., CH



"THE ENGINEER"

—SUPERHEATER SIDE TANK PASSENGER ENGINE

KE, M. [illegible] C.E., CREWE, ENGINEER



SWAIN Sc.

THE COST OF EXCAVATION ON LARGE ENGINEERING WORKS.

No. II.*

THE first trouble experienced in buying a quantity of rails will be the variation in the section and punching for the same weight of rail. The trouble involved in constantly picking over rails to get the same section together is considerable, and where it is imperative to put in another rail at once—as in the case of a spill—if the nearest rail does not happen to be the right section, there is a search for a pair of plates to fish them together, and possibly sending to the smith's shop for a special pair. Just what the cost of this unnecessary work is cannot be stated, but the writer believes that fully 15 per cent. of the total labour in connection with the temporary roads would be saved if the rails were all one section and one punching. For the expenditure on sleepers, very little will be returned at the end of the work. The writer's experience is that on a two or three years' contract, the number of sleepers used up will be as follows:— Should all new sleepers be bought, at least one-third will be totally lost, and the remaining two-thirds will be of very little value by the time a purchaser is found for them; they may realise about 1s. less than the price of new sleepers. The market for new sleepers varies from about 1s. 3d. to 1s. 10d. each. If a number are second-hand to start with, the loss will be proportionately greater. Should one-third be second-hand at the start, the loss will be over one-half of the total number brought on to the job. It is obvious that if by using heavier rails one sleeper per pair of 30ft. rails can be saved, there will be considerable saving when several miles of road are required.

On ordinary ground short fish-plates, weighing about 12 lb. per pair and having only two holes in each plate, will be quite good enough. On very soft ground long plates with four holes are necessary. The brobs, usually 4in. by ¼in., vary considerably in number from different makers, some only sending about 270, others 300 in 1 cwt. When driven they should not project through the sleeper; if they do, they will knock off a large splinter at the bottom where they are driven. At least one-half of all fastenings will be lost. The quantity of temporary track required can be roughly approximated; on railway and similar work a length equal to about twice the length of the contract, and a fairly accurate idea of the quantities on most kinds of work can be obtained from the general plan, with a liberal allowance for sidings.

Having fixed the approximate quantity, the estimate of cost can be made out. The writer has his costs on a cost per mile per year basis.

	£ s. d.	£ s. d.
Rails, say, 90 tons per mile at £4 per ton	360 0 0	
Interest at 10 per cent. per annum		36 0 0
Sleepers, say, 2000 per mile at 1s. 6d.	150 0 0	
Interest at 10 per cent. per annum	15 0 0	
Loss, one-sixth per annum	25 0 0	
Depreciation of 6d. per sleeper per year	41 13 0	
		81 13 0
Fastenings—		
Brobs at 26 cwt. per mile at 10s. cwt.	13 0 0	
Plates, 12 lb. pair, 21 cwt. per mile at 12s.	12 12 0	
Bolts, 7 cwt. per mile at 13s. ...	4 11 0	
	30 3 0	
Loss, 25 per cent. per annum, say		7 0 0
Cost per year per mile for materials		£125 3 0

The loss of rails is very small, and may be disregarded; in fact, a profit due to a rise in the market is not unknown.

The labour of laying, altering, and maintaining a mile of track for one year will average about £240.

This figure is the average of several contracts, and includes all charges booked to temporary roads, but does not include anything for temporary bridges, say, for carrying the track over a highway, and the general expenses have to be added to it.

The total cost per mile per year is as follows:—

	£ s. d.
Labour	240 0 0
General expenses	80 0 0
Materials	125 3 0
Total	445 3 0

Assuming that 10 miles of road are required on a two years' job. This equals 20 miles for one year, and 20 × £445 3s. = total cost of temporary track; divide this by the total number of cubic yards to be moved, and this will be the cost per cubic yard for temporary roads.

The locomotive power required is more difficult to determine, the daily output, the distance it has to be taken, and the gradient being things to decide this. Each excavator will require at least one locomotive to look after it. There will also be the general shunting to attend to. Should the cutting be near the bank, with no steep gradients to negotiate, a locomotive may be able to straight road and tip its own wagons, if the excavator is not filling more than 500 to 600 cubic yards. If side wagons are being worked, an extra man or two on the bank will often avoid the charge for an additional locomotive. Where end wagons are being tipped, the speed cannot be increased by increasing the men. If the locomotive cannot straight road and tip the wagons from one machine, it may be able to shunt two machines and haul a short distance and marshal the wagons for the other locomotive, which, supposing the grade to be favourable, might be able to haul double sets of side wagons, tip them, and get back in time to keep the excavators going. As everything depends upon local conditions, little can be said to indicate how many locomotives will be required. A speed of not more than eight to ten miles per hour for sets of from 30 to 40 wagons is all that can be allowed with stops of a quarter of an hour or twenty minutes not more than four miles apart for fatting. Allow a quarter of an hour at one end and half an hour at the other for running round the wagons, getting coal and water, and shunting out crippled wagons, &c.

If tipping end wagons are used 300 wagons are all that can be allowed for one engine doing nothing but tip, with banks 20ft. to 30ft. high and wide enough to get a double road on. If the earth is sticky and does not leave the wagons well, 200 will be nearer the average.

End wagons hold about 2½ cubic yards solid, and are much worse to handle in sets than side wagons. The front axle is only about 12in. in front of the centre of the wagon, and the slightest bump causes the earth to slide forward and tip it.

The expenses of working a locomotive depend mostly on the water, to some extent on the gradients, and a little on the coal. Bad water on heavy gradients will ruin a new copper fire-box in less than twelve months.

The writer has never used a modern water softening plant, but has used many of the boiler compounds with poor results. The wages paid to the drivers and firemen while the engine is in the shed, for washing out and repairing, so as to keep the locomotive in good running order, make a considerable addition to the wages paid for actual driving. On one contract the writer found these to add 20 per cent. to the wages paid for useful work done; this 20 per cent. being exclusive of the wages paid to fitters and smiths for helping with repair work. The labour cost of driving and repairing a locomotive on a contract where 3571 shifts were worked came out at 19s. 6d. per shift, including fitters and smiths. The depreciation on locomotives is not so large as on excavators; there is also a better market for them when finished with; 20s. per shift would be a fair average price to allow under ordinary conditions. The repair accounts will depend on the water more than anything else. Assuming the locomotive in good condition to start with, they should not amount to more than 5s. per shift; the oil and stores to about 3s.; water, 1s.; and coal, 1 to 1¼ tons.

When several locomotives are employed, it is advisable to have a foreman to superintend the shunting. There are also a number of boys required for turning points, working signals, and fatting wagons. These will add about 3s. per shift to each locomotive.

Labour cost.

	£ s. d.
Driving and repairing	0 19 6
Foreman and point turners	0 3 0
	1 2 6
General expenses 33⅓%	0 7 6
	£1 10 0

Accounts.

	£ s. d.
Interest and depreciation	1 0 0
Coal, 1 ton at 12s. ...	0 12 0
Repair accounts... ...	0 5 0
Water	0 1 0
Oil and stores	0 3 0
	2 1 0
Labour...	1 10 0
Total cost per shift ...	£3 11 0

The style of wagon most suitable for the work depends on the kind of bank to be tipped, the length of the haul, and the contour of the ground. On a wide bank with slopes flatter than 1½ to 1 over fairly level country, the writer would select side wagons, especially where large quantities have to be dealt with. On an ordinary double line railway bank with 1½ to 1 slope or steeper across a valley he would select end wagons. There is not very much in it under ordinary conditions. In making a short, deep fill, side wagons cannot well be used. They are more generally used now than end wagons, and there is a better market for them when finished with. When loose earth is emptied from an end wagon, the side slope it takes is only about 1 to 1, so that on a bank tipped in this way there is quite a considerable quantity of earth to trim down even for a 1½ to 1 slope. Earth from a side wagon rolls to a flatter slope, and so there is less trimming to be done. On a long haul end tip wagons are much more difficult to deal with, for the reason previously explained, that they so very easily tip, and they hold less. A side wagon will hold 3 cubic yards and an end wagon 2½ cubic yards measured in the solid.

Given the daily output, and the distance it has to be moved, it is not difficult to approximate the number of wagons required. Generally, it takes about 45 side wagons to work a steam excavator if the haul is not more than 1 to 1½ miles and the gradients are such that a 12in. or 13in. locomotive can handle 20 wagons in a set. Where the haul is longer more wagons are, of course, required; sets will be larger, or another locomotive will be required. Sets of 40 wagons cannot be hauled safely at more than about eight miles an hour. On a long run there will be delays due to one train waiting for another at passing places. There is the time required for tipping on the bank, and if the wagons have to tip both ways, as they have for lifting a side wagon bank, there will be time lost doing this shunting to get all the wagons tipping the same way together, and where several steam excavators are at work this is almost unavoidable.

As an illustration of how the number of wagons may be estimated, take a case where two steam excavators are at work, the earth having to be hauled a distance of three miles. Assume it is good filling, say an average of 500 cubic yards each machine a day, and gradients are such that a locomotive will handle up to forty wagons in a set. The daily output in wagons will be $\frac{1000}{3} = 334$, say. One locomotive shunts both excavators, and marshals the wagons for the straight road locomotive. The latter is assumed to travel at eight miles per hour, and tip its own wagons. The time required to haul full wagons will be about half-hour. The tipping and shunting on the bank will on fairly straightforward work take about three-quarter of an hour, and the return journey half an hour, a total of 1¾ hours per trip, or five to six trips per day. Then $\frac{334}{6}$, or 56, is the size of the set to deal with this quantity of excavation. The locomotive being only able to handle 40, an additional locomotive will be wanted on the bank to tip a set while a set is travelling. Relieved of the tipping, the straight-road locomotive would make the trip in about one hour; allowing, say, one hour per day for getting coal and water and shunting out cripples, it would make nine trips per day. Then $\frac{334}{9}$, or 37 wagons per set, will keep the excavators busy, and is within the capacity of the locomotive. The time for each trip would be $\frac{600}{9}$ min. = 66 minutes. The excavators would then have to have enough wagons to last 66 minutes. There are then 37 wagons being filled, 37 on the way, and 37 being tipped—a total of 111 wagons. Generally 10 per cent. of them will be undergoing repairs, or a total of 122 wagons would just suffice to keep going, provided there was no delay of any sort. Delays will occur, and must be allowed for. Also it must be remembered that to average 500 cubic yards per day very much larger quantities must be excavated on some days to make up for the loss on others. Of course, both machines may not have their good days together, but when only two are at work they may. The writer would allow at least 50 per cent. more wagons than calculated as above, providing the two machines were filling close together, so that those wagons not required at one machine could be quickly moved to the other. Should they be working under conditions which rendered the easy movement of wagons from one to the other impracticable, he would allow 75 per cent. more than calculated. New side wagons cost from £28 to £30 each, but good second-hand ones can be had from about £12 to £13 each, and these are usually bought. Maintaining wagons in good running order is an expensive item, and to some extent depends on the kind of excavation being dealt with, rock being much more severe on the wagon bodies than earth. The writer's records vary very considerably for the cost, from ¼d. to 1d. per cubic yard per mile, and for an estimate he would adopt the latter figure. Second-hand wagons will suffer very little depreciation in value, if well maintained.

At a 1d. per cubic yard per mile, the average distance the excavation has to be moved in miles regarded as pence gives the cost per cubic yard for wagons.

The tipping cost is purely a labour one, unless there is a locomotive doing nothing else. It largely depends on the kind of earth to be tipped; also on the depth and width of the bank. A very shallow bank is more expensive per cubic yard than one 20ft. to 30ft. deep, because there is so much more platelaying to do when tipping end wagons, and the expensive part of side tipping is lifting the first few feet. If the earth is at all inclined to stick to the wagons, end tips are not so good as side; they often go straight over the tip end, causing delay in getting them up and damaging the wagon. Side wagons can be chained to the road so that they don't go right over. Where possible it is advisable not to mix the two styles of wagons on the same work; doing so causes an excessive amount of shunting to get them together.

In lifting a side wagon bank, the road is first laid on the surface, a set of wagons all tipping the same way are pushed on and emptied. The road is then lifted on that side 2in. or 3in. above the opposite rail, the next set of wagons tip the opposite side to the last set; the second rail is then lifted 2in. or 3in. above the first, the operations being continued until the road is raised to the required height. The labour cost of tipping and lifting the road through the first 10ft. will cost from 1¼d. to 1¾d. per cubic yard; above this from 1d. to 1¼d. per cubic yard. These prices are for the labour only, and do not include locomotive cost. The corresponding cost for the labour of emptying end wagons on, say, a 10ft. bank would be, assuming the earth leaves the wagons allright, about .80d. per cubic yard. They will have to be shortened up every week end, which will cost a further .45d. per cubic yard. A locomotive, if required at £3 11s. per day, will add 1.2d. per cubic yard, or a total of 2.45d. per cubic yard.

Should the bank be less than 10ft. deep, and the shortening up have to be done twice a week, this item will be correspondingly increased, and when deeper it is reduced, as is also the labour cost of emptying, owing to there being less metalling ahead for the same quantity. Should the excavator be filling only about 400 to 500 cubic yards, and not more than a mile away, the locomotive would haul and tip the wagons, and so no locomotive would be charged to tipping. About 300 end wagons is as many as can be averaged over one bank end (with two roads) in a day, under good conditions; that is, with a good shoot and earth that does not stick to the wagons. It will require a locomotive doing nothing else to empty this quantity. A fair average cost for tipping a bank 25ft. to 30ft. wide, 20ft. deep, with good muck would be:—

	d.
Labour, emptying	0.80
,, shortening up	0.20
General expenses	0.33
Locomotive	1.20
Total	2.53

Taking the shortening up out, as it has already been included under the heading of temporary roads in the average cost per mile per year, would reduce the estimate to 2¼d. per cubic yard.

As previously mentioned, the side slopes of an end tip bank usually take a slope of about 1 to 1. Should this have to be trimmed down to 1½ to 1, the bank has to be tipped wider than shown on the sections to allow for it. Usually the trimming is paid for at a separate price per square yard of slope trimmed and soiled, which is the best way to pay. The cost of trimming—not including soiling—loose earth down a bank is not expensive unless the bank is very deep. For shale banks of average depth about 1¼d. per square yard, trimmed. For very rough material on a bank 60ft. deep the writer has one case where it cost 3½d. per square yard.

* No. I. appeared June 23rd.

If the work is not given separately it must be measured up and added to the cost of tipping.

It will be seen that however experienced and able the estimator may be, he cannot be quite certain that his price is correct, there is such a very wide field for wrong assumptions and errors of judgment. If to this is added a number of so-called sword clauses, which may or may not be enforced, and it has to include things over which he has no control, his estimate ceases to be anything but an intelligent guess.

THE TURIN EXHIBITION.

(By a Special Correspondent in Italy.)

No. V.*

THE ENGLISH SECTION.

THE British pavilion—see plan—is perhaps the most imposing in the Exhibition; it has undoubtedly the best position. Occupying more than 65,000 sq. ft., and with its central cupola 130ft. high, it forms with its colonnade a sort of upper gallery to the semi-circular theatre which, embracing the lower levels occupied by the monumental fountain and the carriage drive, descends in ever lessening tiers to the principal exhibit, that of the agricultural machines, drawn up on the right and left of the gangway which runs down the centre, with, at the head of the double line and immediately under the gallery, the large stand of Ruston, Proctor and Co., Limited, one of the most impressive in the whole Turin Exhibition for intrinsic merit combined with perfect "setting out." It comprises a complete threshing set, shown in motion, consisting of a 4ft. 6in. thresher and portable steam engine, 20-25 horse-power, 12 atmospheres, with superheater and feed-water heater; a 3ft. 6in. clover huller of newest type with ring-oiling bearings on the swivel principle for obviating friction when the machine is on uneven ground; and one of the firm's latest 40 brake horse-power crude oil engines guaranteed to work with Italian refuse oil for 3 centimes per horse-power per hour. There is also a 12½-ton roller, using superheated steam, and fitted with a scarifier; a 75 brake horse-power suction gas engine and producer, with patented arrangement for shutting off the scrubber from the generator to avoid any risk of explosion in the producer; a 20 brake horse-power portable oil engine for crude oil; a small portable engine; a straw press for working independently or behind threshers; and a 6in. centrifugal pump. The attention bestowed on the minutest details redounds to

PLAN OF THE BRITISH PAVILION

slopes which lead down to the river. The architecture is of the prevailing eighteenth century Piedmontese style called "Turinese," though introduced by Filippo Juvara of Messina, and the English Committee has done well in its choice of colour, which is the warm yellow of the Italian "travertino."

The approach from the river affords a comprehensive view of the exterior of the building. To visit the interior, however, the secondary entrance is preferable. It leads through the fireproof-screened arch which connects the section with the central power station, and communicates directly with the raised gallery dominating the principal, or "machinery," hall, 500ft. long and 150ft. wide, with its walls, of an unnoticeable tint, hung with the flags of the principal English towns.

The exhibits are beautifully arranged. They are much less massed together than in the generality of other pavilions, and are therefore less tiring to the eye. They are classified not only scientifically, but artistically. And another impression which strikes the senses is the comparative silence, the reverse of the effect produced by the Swiss section. Here there is the suggestion of power in repose; there the proclamation of power in action.

Half the length of the entire hall is filled by the

* No. IV. appeared June 16th.

the credit of a commercial house long known in Italy, of their trade, and of their country. "Si vede che è roba inglese!" is the general exclamation—"One can see that it is English work!" The Lincoln firm could desire no higher compliment in Italy. Photographs of two of the items are reproduced on page 661.

From this stand the exhibits divide, as described, to right and left of the central gangway running down the hall. Here are to be found exhibits by Garrett and Sons, Marshall, Sons and Co., Clayton and Shuttleworth, and J. and H. McLaren, Alley and McLellan—a Sentinel steam wagon—and Fowler and Co. The exhibits are all well arranged, but it is unnecessary to say much about them, as the items are already familiar to most of your readers. Messrs. Blackstone and the Martin Company, of Stamford, show swath turners, cultivators, and rakes. This latter exhibit, though small, is excellent in workmanship and finish, and compares most favourably with those shown by other nations, but the stand may easily pass unnoticed on account of its being the only one in the English section for harvesting machinery. Germany and Hungary, on the other hand, have both of them made efforts on a large scale in this category, for the ubiquitous energy of the former is tending to diminish the long lead of America, while the latter is bidding for the third place, now held by England. For even this is not to be scouted in a total import in the last three years of upwards of 4 million, and of 6½ million francs for reapers and harvesters alone respectively, to say nothing of the vast agricultural future still before this country as draining brings to light fresh virgin soil, and conquers the scourge of malaria. It has therefore caused surprise that England should not be more amply represented in the light implement department, for in Italy we look on the Turin Exhibition seriously, and presume that every nation shows what she excels in, provided that there is, or may be, a market for it here. It is hard for us, given the high pressure conditions of modern commerce, to enter into the English persuasion that these international manifestations of human industry can be neglected, and reliance placed solely on active agencies; for, putting patriotism aside, we do not see the advisability of dispensing with any means of asserting worth, and as to active agencies, we cannot help noticing that, as far as this country is concerned, they are to a preponderating extent "made in Germany."

But an instance of the contrary is to be found in the heavy agricultural machinery industry. The list of English exhibitors already mentioned is a thoroughly representative one in our eyes, for it embraces the names of all those firms who have for years formed the nucleus of the trade here. These have all of them active agencies, and they have to be very active ones too, for they are handicapped by large transport expenses, high wages, the extra cost entailed by perfect finish, and conditions of payment which here are considered onerous; but in spite of these disadvantages they yet continue to supply most of the plant on the richer Italian properties where implements are of the highest quality. Their great rival Germany, besides being in this branch of business as in others more lenient in the matter of long draft bills, does solid work and well finished, but it is much less graceful, bulky for transport on narrow Italian roads, and of greater weight. Thrashers of this type are to be seen working on the admirable stands of Lanz, of Mannheim, and Wolf, of Magdeburg, in the general agricultural section. The same criticism of excessive heaviness may be applied also to the threshing machines of Seck, of Trieste, while his ploughs, harrows, and other light implements show traces of hasty manufacture.

A surprise has been prepared, even to those in the trade, by the Hungarian exhibit, which is of quite a different type to the German, and is represented by the well-known Hopherr-Schrantz, of Kispest, by the Hungarian State Works in Buda-Pest, and by Messrs. Basch and Tarján. The latter has a good show of ploughs and drills. Of the two former, the first has a large stand on which the principal items are engines, threshers, an automatic forage cutter, binder and press, a straw cutter and a reaper, together with fans and drills; the second has a very fine tractor, two threshers, and three portable engines. The exhibit is artistically set out, and the workmanship and finish of a high class, while for lightness and grace of line the Hungarian State work bears a close similarity to that of England.

The exhibit of our own home makers is represented by a good many houses, among whom Ernesto Breda, of Milan, and Casali, of Suzzara, are certainly the best. The work is sound, while, as far as shape and system are concerned, an attentive examination leads to the firm conviction that some of the machines are faithfully copied from English models. And yet the result is different, for, making every allowance for the superior "dressing" of the English "show" exhibits—and especially of those of Ruston, Proctor and Co., Ld.—the finish of our home makers is normally inferior, and it is futile to deny this fact. Against them, too, is the extra value set by the world on an undoubted original, especially if the author be of proved merit. On the other hand, they offer an immense advantage to small capitalists in extreme facility for payment, which is prolonged in some cases up to five and six years; and the policy is a sound one, for by its means the clientele is being formed more rapidly, and year by year more confidence is won in ever-growing experience and betterments.

I have made this digression whilst treating of the English section because of the fact that agricultural machinery is rightly shown by England in Turin as her chief exhibit. In this branch she has never lost her lead, and the position held by good work and straight dealing will become still more important as the cultivated area is enlarged, and agricultural methods prevalent in the days of Augustus Cæsar yield before modern science. A vast agricultural future is now opening before Italy. The home supply of machinery is increasing in quality and volume, but will probably not be able to render the country independent of foreign imports in the case of the first-rate article for many years. Given the keenness of the foreign competition to make good what may be lacking, the English show—the best in the Exhibition—is, from the point of view of her prestige and material advantage, not only imposing, but opportune.

Behind this department are ranged down the wall of the gallery the smaller stands, in number about twenty. The Underfeed Stoker Co. exhibits a full sized model, and Watson-Laidlaw centrifugal oil extractors and water extractors for the sugar industry, while there is a well-arranged show of chains by Hans Renold, and Merryweather's fire-engines compare favourably with the French exhibit in another section. Turners, of Ipswich have a flour mill, and Petters, of Yeovil, a good line of their crude oil engines, a practical show here, where engines made to burn Italian residue oil—with a specific gravity of .947 at 60 deg. Fah., as against .875 for Russian crude oil—have a likely market, as the said fuel costs 9.5 lira, duty comprised, per 100 kilos.

The end of the room is occupied by the textile machinery, of which the principal exhibitors are Brooks and Doxey, McGee, of Paisley, the British Northrop Loom Company, and Messrs. Hacking, of Bury, who show ten machines between looms, winders and plaiters, and by Messrs. Herbert's (of Coventry) excellent stand of their well-known automatic and semi-automatic machine tools. The exhibit is practically arranged as a sort of

model workshop with a steel superstructure over it, carrying the main driving motor which transmits the powers to the main shaft through a Westinghouse chain drive. In addition to a complete line of small tools, there are about eighteen machines in actual operation, including hexagon, turret, and capstan lathes, ball bearing sensitive drilling machines, vertical and horizontal milling machines, a complete line of grinding machinery (including the "Lumsden" oscillating tool grinder exhibited for the first time out of England), a "David Brown" bevel gear shaper, and a "Wadkin" wood-working machine with self-contained motor drive doing core box and moulding work. A new model automatic screw machine is attracting particular attention. This has the self-selecting feed motion, roller steady turning tools, and the "Coventry" self-opening die head It is producing, out of 25-ton tensile steel, screws of the following dimensions in 1 min. 40 sec.:—Diameter, bolt, ⅜in.; head, 1¼in.; length under head, 2⅜in.; total length, 3¼in.; Whitworth thread, 1⅜in. long, 11 threads per inch. It is a pity that there are not more stands of this calibre, for the trade is one in which England once held the monopoly here.

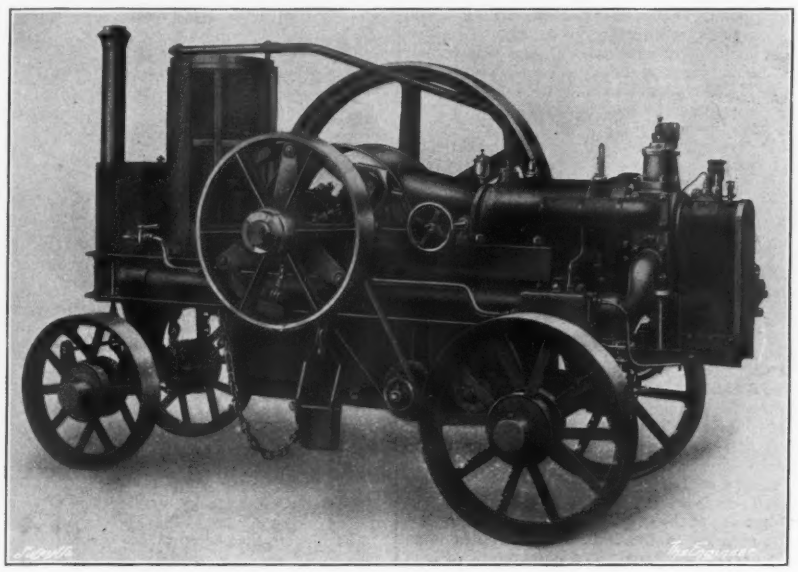
Opposite this stand are the engines which supply the section with power and light, the latter being calculated to the exhibitors at 4d. per kilowatt-hour, instead of 1f. as paid by the sections dependent on the general committee. They consist of two Hornsby suction gas engines of 100 horse-power each, 210 revolutions, and a suction gas plant by the Campbell Gas Engine Company consisting of two vertical four-cylinder engines, with forced lubrication to main bearings, 290 and 150 brake horse-power, direct coupled to Phœnix generators of 190 and 100 kilowatts, and a horizontal 120 brake horse-power engine, with throttle governor, driving a Phœnix 80-kilowatt dynamo through laminated leather belt. These engines depend on suction-gas open-hearth plants burning anthracite peas. The Halifax firm has also a show stand opposite with a stationary engine, 15 brake horse-power, and a portable 10½ brake horse-power engine, lampless after starting type, for refined or semi-refined oils, and a 35 brake horse-power high-compression lampless engine for crude oils.

Returning to the upper end of the hall is to be seen an exhibit which comprises practically every great firm engaged in the trade in England. It is that of motor cars and bicycles. This industry which is full of vigour and modern commercial spirit, has in the last two years taken the first place from Germany in bicycles, and by rises of more than £50,000 a year is now almost level with her in that of bicycle parts. The importance of this latter branch may be gauged from the fact that England exported in 1909 more than £144,000 worth of "parts" into Italy, being about an eighth of her total export. Though here there are several good manufacturing firms, notably the Bianchi, the demand is as yet much greater than the supply, and the import trade, especially of "parts," in which branch Italian houses have not yet specialised themselves, bids fair to be for years to come an item well worth contending for. Among the thirty-four exhibiting firms the B.S.A. Company, the Triumph, and the Rudge-Whitworth are, perhaps, the most prominent for cycles, while for "parts" Dunlop, Hans Renold, the Rover Company, Brampton's and Bluemel's have all stands which leave little to be desired for artistic arrangement of excellent work.

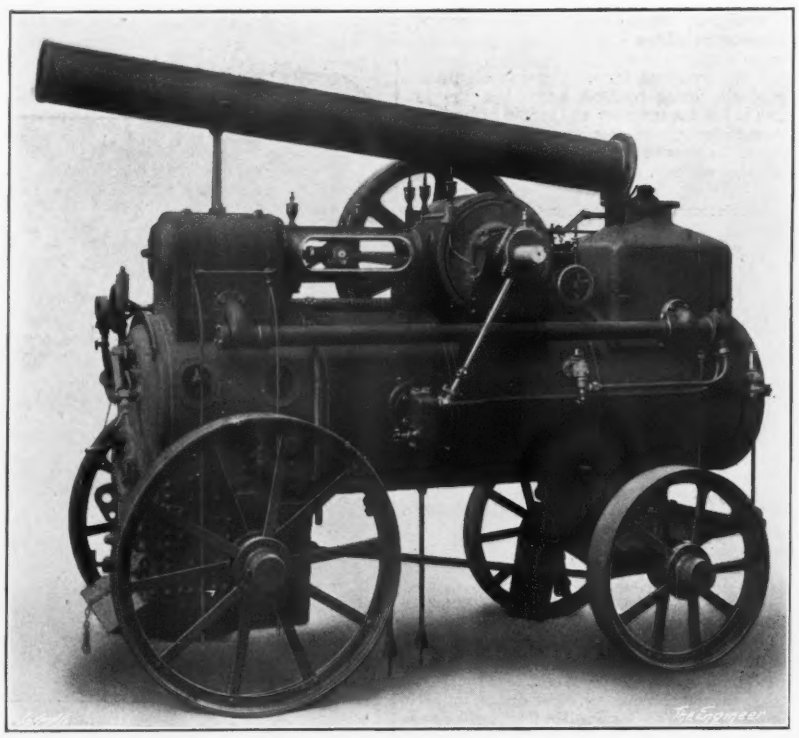
The motor car show meets with special admiration, not only for the quality of the exhibits, but for the sporting and patriotic spirit which has prompted the promoters to transport heavy and valuable material into the town of Fiat, Itala, and Diatto-Clément, the very citadel of the famous motor car trade of Italy. The proportions of the industry in England were here unknown. Before this exhibit her work was vaguely considered as lacking in grace, finish, and speed. The latter is now less sought after, and durability and hill-climbing powers, comfort and finish, represent the ideal car. These English motors get the credit of the first two qualities, and they undoubtedly have the two last, while in beauty of line they are certainly equal to our own, and in varnish perhaps superior. In the eleven firms represented, with their thirteen cars and two chassis, the standard of excellence is of the highest order; the admiration bestowed on Daimler's dark green touring car with Silent Knight engine and on Edge's limousine landaulette with Mulliner body is universal. The English motor show, which was arranged by the Society of Motor Manufacturers and Traders, will, in Italian opinion, be followed by solid advantage to her trade. Behind this exhibit, in a sort of apse of the Machinery Hall, are the chemical industries and Tudor palace, whose characteristic entrance gate leads to the furniture department, a section put together with the object of stimulating English export in a branch of her commerce whose merits here are almost unknown. Beyond this are the textile and clothing sections, scantily represented, and the leather industry, which might, with advantage to itself, have made a better exhibit in a country where the English article is sought after even at the higher price which it bears in respect to that of Germany. The sections devoted to food products, prints and photography present little of special interest.

Of the remaining exhibits, that of the Bradford Chamber of Commerce, occupying a space of 160ft. by 60ft., is devoted to illustrating the phases of that vastly important branch of English commerce here—the wool trade. In a series of rooms of about 30ft. by 20ft. each, is shown, by means of waxwork figures and real machinery, the history of the industry from the sheep on the moors, through the processes of sorting, combing, spinning, weaving, and dyeing, to the finished article made into clothing for Henley, for the covert side, and for the opera. The exhibit is realistic and suggestive, instructive, and popular.

The last two sections seen before leaving the building are those dedicated to books and ceramics, and are two of the most generally interesting in the English pavilion. The former is presented in the attractive form of a library, in which all the greatest publishing houses of England have co-operated, and where later on the public will be allowed to read editions whose bindings, illustrations, letter-print, and paper are what the world of to-day may call perfection. The latter is a revelation to Italy. The excellence of English ceramics of the domestic type has long been appreciated, as is shown by the heavy import, but the power of fashioning objects of high artistic value, such as here are to be seen, was thought to rest with other nations. For variety and elegance, for glaze, colour, and painting, English potters have proved themselves worthy descendants of Astbury and Josiah Wedgwood. The British section in the Turin Exhibition is the object of interest, of praise, and of satisfaction. In the agricultural machinery department it is hoped that the difficulties of the undertaking are compensated to the exhibitors by the success of their efforts and by the commercial importance of the industry. In the land transport section, in books, and in ceramics, the nation is worthily represented in its ingenuity, its enlightenment, and its art. The general organisation and arrangement, care of detail, and prevailing good taste are remarkable. Finally, it is the first time that England has exhibited as a nation here, and the coincidence of the fact with the celebration of Italian unity tends further to strengthen the bonds of friendship which every Italian feels for the nation that befriended his country in those fevered days just fifty years ago.



PORTABLE OIL ENGINE—RUSTON, PROCTOR AND CO., LIMITED



PORTABLE STEAM ENGINE—RUSTON, PROCTOR AND CO., LIMITED

THE BRITISH INVENTOR: HIS DECADENCE AND THE REMEDY.

By W. O. HORSNAILL, A.M.I. Mech. E., A.M.I.E.E.

THE prosperity of a manufacturing country depends to a large extent upon the fertility of the native inventor, and the inducement offered him to develop his ideas into a practical form. Of late years this country has, unfortunately, fallen behind some others as regards the evolution of useful inventions, and it behoves us carefully to consider the causes which have led up to this regrettable condition, with a view to their removal.

The early development of electrical machinery and motor cars in the United Kingdom was undoubtedly hampered by ill-considered legislation; but we cannot plead this excuse for our failure to keep pace with France and Germany in perfecting the aeroplane and airship. The production of new inventions on any considerable scale will only take place under the encouragement offered by a reasonable probability of material reward, and it is to be feared that the chances of the latter are too remote in this country to command the efforts of our best men, hence many potential inventors are wasting their energies over routine work, which could be performed equally well by those possessing no inventive ability. The attitude of the British manufacturer towards new inventions is one of apathy coupled with extreme scepticism, and he can only be induced to take up a new patent under an agreement giving him the lion's share of the profits, whilst the unfortunate patentee is saddled with all the risks.

The majority of ideas cannot be put into workable shape without patient and often costly experimenting, hence an inventor without means of his own must apply either to a capitalist or a manufacturer for assistance. The former is very chary of risking his money on such ventures, in view of the attitude of the manufacturer indicated above, and the latter, if he can be persuaded to take any interest at all in the idea stage, will suggest employing the inventor under an agreement by which he

surrenders all claims to any improvements resulting from his efforts. This state of things compares unfavourably with the attitude of manufacturers towards inventions in certain other countries who now give us the lead in this line.

In view of the epoch-making inventions brought out by British enterprise during the last century, it is difficult to believe that our inventors are suffering from any lack of originality, this view being further supported by the large and increasing number of applications for letters patent. Such being the case, we are driven to the conclusion that the chances of a reward, which were good enough to attract the best brains in the country thirty to fifty years ago, have now become too remote to act in this way, with the result that our manufacturers have been reduced to copying the inventions of other nations. There is little room for doubt that the position is mainly governed by the attitude of the manufacturer, both as regards the independent inventor and his own employees.

From the employer's point of view, an agreement of some sort with his technical staff as to the taking out of patents is necessary, otherwise an unscrupulous workman might protect an invention in his own name which was the outcome of experimental work carried on at the expense of the firm. As a safeguard against this line of conduct an agreement surrendering all claims for inventions in connection with his work should be signed by each member of the staff whose duties would enable him to act in this way. At the same time it should be made clear that the firm is willing to pay a royalty to anyone who invents a new device or machine which is worthy of being manufactured.

If, instead of taking this course, the agreement is strictly enforced, a great deal of inventive effort must be lost, as the chances of reward in any other form than a royalty are too remote to be effective.

It is not intended to suggest that the majority of British firms make no recompense whatever to workpeople who bring forward valuable inventions, but the reward is generally in the form of a small increase in salary, which may, and often does, end after a short period owing to a revision of the staff appointments. Only a very few manufacturers employ experimenters whose whole duty consists in developing new products, and the chances of a small increase of salary for an uncertain period are not sufficiently attractive to induce inventive efforts in those who have been engaged for other duties; hence, if a good idea is thought of, the experienced assistant will keep it to himself until he secures a new appointment, when protection can be obtained between engagements.

Some old-fasioned people may be inclined to designate such a course as "dishonourable," the contention being that the employer is entitled to every effort made by his staff. This view might have been supported many years ago, when a sense of duty was held by both parties, and workmen were only dismissed for grave misbehaviour or obvious incompetency. The present conditions under which members of the staff are given notice during slack periods, or because juniors can be promoted at a reduced salary, are not favourable to such a sense of duty as would cause the disclosure of valuable ideas developed during a man's spare time.

It is difficult to understand what objection there can be to paying a small royalty to a workman. It would have to be paid to an independent inventor, and, after all, the firm is placed under no permanent obligation, as the royalty ceases with the manufacture; moreover, much better terms can be arranged than would be practicable in taking up the invention of an outsider. It is only fair to state that certain enlightened firms have been very liberal with members of their staff who have brought out new inventions and such concerns have greatly benefited by this procedure, but the general rule is to give no royalties to workmen, whether engaged for experimental work or other duties.

One reason for our lack of success in the direction of new inventions is the neglect of experimental and research work by manufacturing concerns. Inventive skill and capacity for executive or routine work are seldom combined in one individual; yet many of our large manufacturers depend upon their executive officers to bring out new lines of products. This plan is in marked contrast to the methods pursued in Germany, where almost every large works has a number of men continually engaged upon experimental and research work, no attempt being made to economise in this department even during periods of depression. Signs are not wanting that the British manufacturer is waking up to the importance of continual development, but he must be prepared adequately to reward those who suggest valuable improvements if the best results are to be obtained.

Turning our attention to the independent inventor, it is probable that his failure to maintain his reputation with the manufacturer has been brought about largely by the reduction in the patent fees. Fifty years ago the taking out of letters patent was a very costly process, consequently few inventions were thus protected, and more trouble was taken to perfect them. With the reduced fees the number of applications for patents increased very rapidly, protection being sought without any serious investigation as to the value of the inventions.

Manufacturers and capitalists are bombarded with overtures regarding useless inventions which would be at once condemned by any expert in the industry concerned, the natural result being that inventors are considered in the main to consist of cranks and faddists. This view receives further support from the Patent-office records, which show that at least 90 per cent. of the applications for letters patent are for useless or anticipated devices, and it is probable that even a greater proportion is never subsequently developed.

The reckless manner in which useless patents are taken out is astonishing. Many inventors with the means to do so spend considerable sums in protecting ideas which have no value whatever, and it is to be feared that their needy brethren not unfrequently throw away their hardly earned savings for a similar purpose. Naturally these gentry are not discouraged by patent agents, many of whom would soon have to close their doors if applications were confined to inventions which were likely to prove successful. One would suppose that when a man set out to invent a device or machine for a certain purpose he would at least find out whether his idea had been anticipated, yet such is not generally the case, and the patent records before the "search rule" came into force show dozens of applications for practically the same invention.

Then, again, the cost of manufacture is often entirely ignored, but it is obviously useless to protect a device which cannot be made for a price at which it is likely to sell. It would appear that an inventor, if he is not an expert in the industry to which his idea applies, would often be well advised in consulting some one whose knowledge and experience would enable him to say whether the invention was likely to prove successful, and this course should be pursued before any money is spent upon taking out a patent. It will no doubt be contended that by such procedure the inventor risks having his idea taken from him for the use of some one else. If, however, care is exercised in the selection of an expert, this risk should be infinitesimal, and in the case of a useless invention the outlay upon patent fees, experiments, models, and attempts to sell, are saved.

Then, again, expert knowledge is necessary for the perfecting of an invention before any attempt is made to place it on the market, and if the inventor does not possess such knowledge he should certainly seek assistance.

Many good inventions have failed because they have been offered to manufacturers in an imperfect state, backed up by inefficient designs and carelessly constructed models. The drawings of the invention, and the workmanship of the model, are most important when it is desired to sell a patent. A number of mechanical inventions have made a market for themselves without possessing any merit whatever, excepting they have been well designed and made, whilst others, with novel and useful features of considerable value, have failed to receive recognition owing to the careless way in which they have been put forward.

The consideration of the subject would not be complete without some allusion to the influence of science upon the methods of the inventor. The old system of trial and error is giving place to scientific investigation, and instead of stumbling upon new devices to which a theory is afterwards fitted, this order is reversed. Furthermore, our knowledge on every subject has been vastly extended, and advantage is taken of the work of previous investigators to avoid experimenting with devices already known to be useless. This principle may be carried to an extent depending upon existing knowledge, and the inventor's power of applying it, such being the direction in which Germany is beating us. Their inventors are men with a scientific training and who appreciate the advantages of being *au fait* with all the existing knowledge in connection with any new machine or process it is proposed to develop, hence less time is wasted over useless experiments, and the results are more perfect.

In conclusion, the writer would advocate:—First, the employment by all manufacturers of scientifically trained investigators, whose best efforts are ensured by the prospect of royalties; secondly, expert assistance for independent inventors whose knowledge is insufficient to enable them to estimate the value of their ideas or to develop them into practical form. These recommendations are gradually being realised, and when the full effect of them is felt the inventor will regain his prestige with the manufacturer, and this country will need no longer to rely on the humiliating expedient of copying the inventions of other nations.

THE NEW CODY AEROPLANE.

THE Cody biplane about to be described, which belongs to the tailless order, possesses several novelties which are likely to be severely tested in the forthcoming 1000-mile air race, especially if windy weather prevails. It will be recollected that Mr. S. F. Cody, who introduced his first man-lifting kite over eight years ago, was the inventor of the "Flyer," upon which he eventually won the British Empire Michelin Trophy of last year. His machine, which covered 185 miles 787 yards in 4 hours 47 minutes, has held three all-British records for duration, speed and distance. The total weight carried upon the above-mentioned occasion was 2168 lb. The engine itself weighed 456 lb., and was guaranteed to develop 80 horse-power.

The machine which Mr. Cody introduced in 1909 was of smaller dimensions than his previous designs, and possessed the novelty that it was driven by two motors, but had only one propeller. These engines failed to run well together, so Mr. Cody removed one and accomplished all his successful flying, which is about 2000 miles up to date, with the other, a 60 horse power Green engine, without reducing the size of the aerofoils.

The span of the later machine, introduced in 1910, was 46ft., and it was notable, as was the first, for the wide gap between the upper and lower planes. It had two elevating planes in front, one upon each side, which moved either together or in opposition for stability purposes, there being a single vertical rudder plane at the back, and, in combination therewith, a small horizontal tail, which latter feature is still to be found on the double rudders of Mr. Cody's newest machine.

For elevating and depressing the new biplane, which will be in operation within the next few days for the first time, two large planes are mounted 15ft. in advance of the front edge of the main planes. These "elevators" are monoplane in character, and are approximately the same size as the wings of a racing Blériot. They can, as in previous designs, be worked independently or together. They then serve to elevate or depress the machine bodily, or, when moved independently and in opposition to one another, they tend to retain the lateral balance as a bird does with its wings; and it is due to the quick control secured by these elevators that the machine is expected to obtain a perfectly steady travel in flight.

The steering gear consists of two rudders of equal size, mounted approximately 14ft. to the rear of the propellers. These rudders are of light framework covered with Pegamoid, measuring 6ft. by 4ft. 6in., and are intersected horizontally at their centres by discs of similar material and of a little less diameter than the width of the rudders. The right-hand rudder gives a pull upward by means of its intersecting disc, and the disc of the left-hand rudder pulls in the opposite direction, viz., downward. This is

THE 11ft. 6in. PROPELLER

a novel feature adopted by Mr. Cody for the purpose of counteracting the torque, or gyroscopic twist, set up by the engine and the propeller as they both move in the same direction, viz., anti-clockwise, looking from the rear. The rudders pivot laterally upon their axes, which are perpendicular, and are used for maintaining the direction and lateral balance of the machine during flight. Both rudders and elevators are held in position by moderately stout bamboo poles, and this is the sole purpose for which bamboo is introduced in the structure.

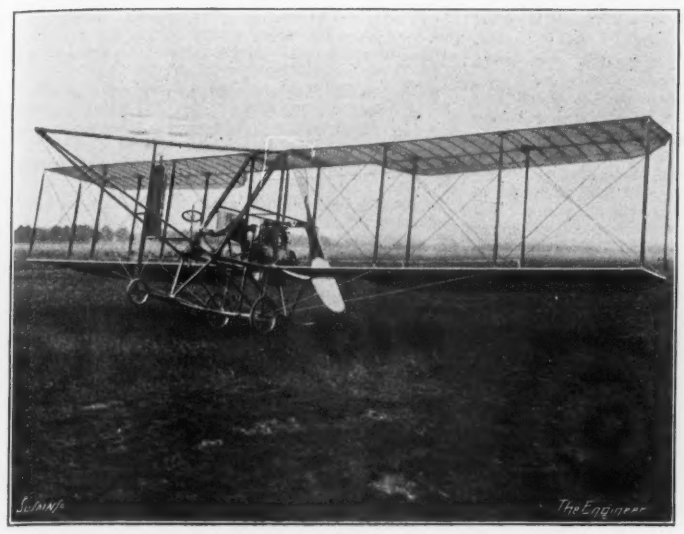
The main wings of the biplane are five in number, viz., two upper and lower sets with one small piece placed over the centre section. The lower wings are of a precisely similar nature to the upper, and are interchangeable with them. The framework of the wings is constructed of silver-spruce wood, the main ribs being made of hickory. The covering material is Pegamoid, sewn with

FRONT VIEW OF CENTRE SECTION

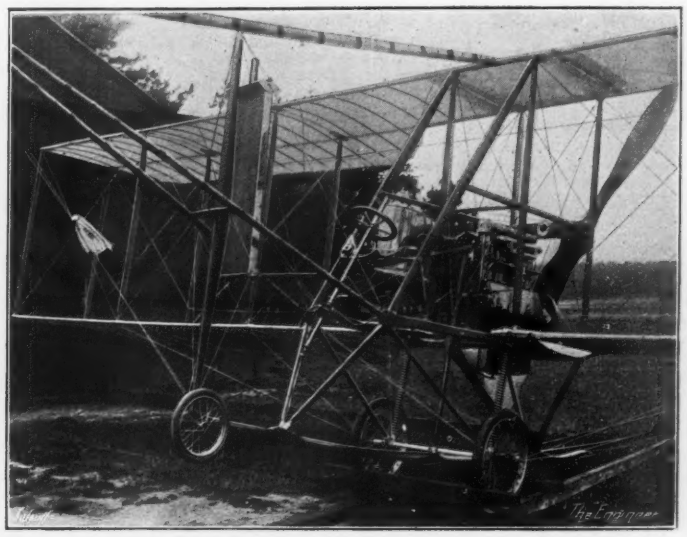
ordinary thread and stretched very tightly across the framework. The curvature, or camber, of the wings is of a patented type introduced by the inventor, and is adjustable to the speed required. At the tips of the lower wings there are fixed two small wheels—not shown in the accompanying engravings—the use of which considerably simplifies the starting and the alighting, as well as general manœuvring upon the ground. The earlier machine, when used at Brooklands recently, made nearly a complete circle with one of its wing wheels touching the ground, while the wheel on the opposite wing was from 6ft. to 15ft. above the ground.

The centre section is constructed of hickory wood, aluminium and steel—mostly spring steel. Its design

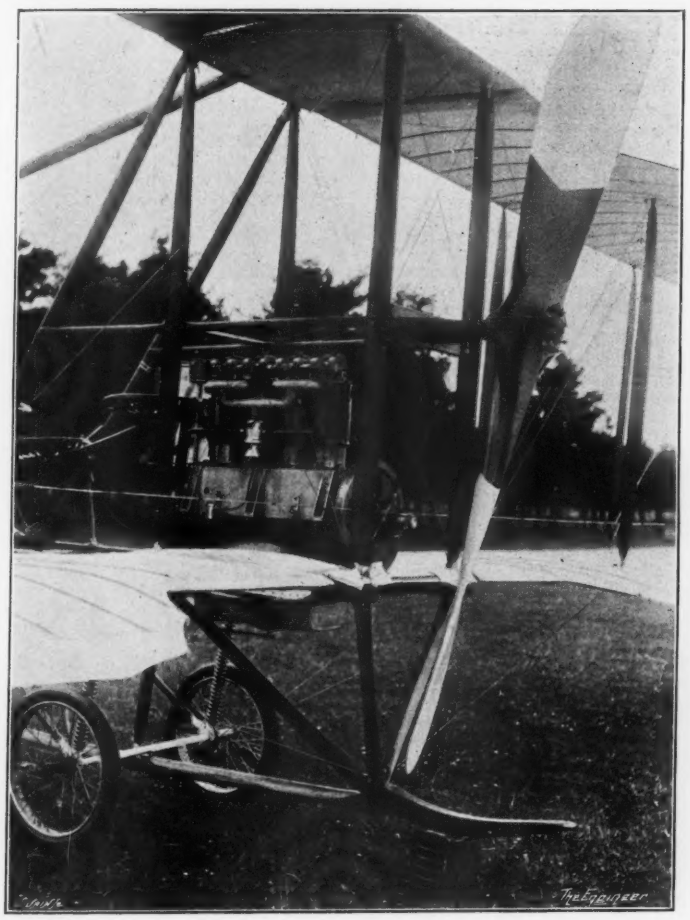
THE NEW CODY AEROPLANE



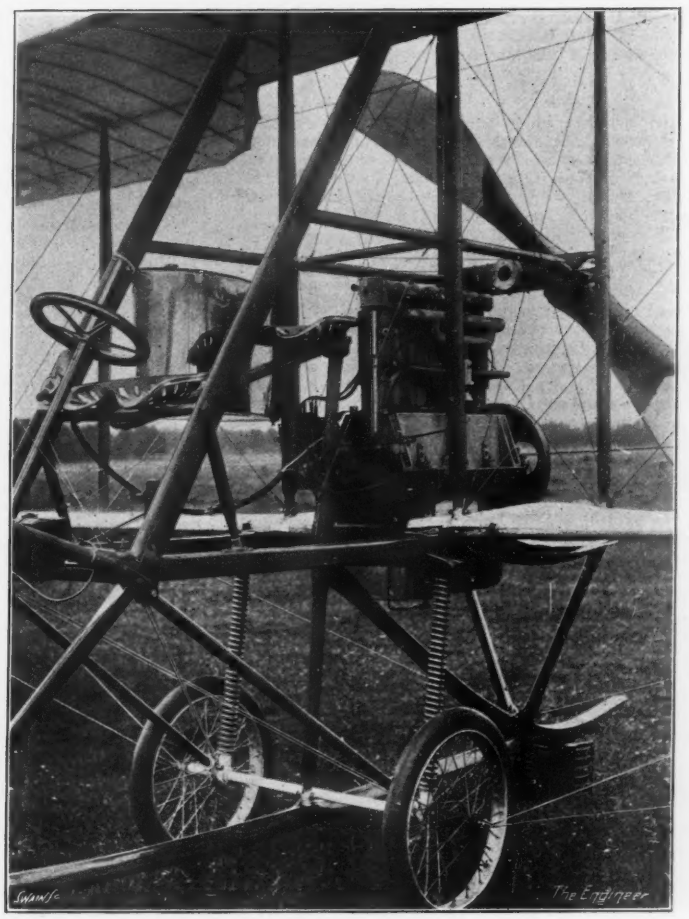
SIDE VIEW OF AEROPLANE WITHOUT ELEVATING OR DEPRESSING PLANES



VIEW OF CENTRE SECTION



REAR SIDE VIEW, SHOWING GREEN ENGINE



FRONT SIDE VIEW, SHOWING ENGINE AND PROPELLER

is the standard "Cody" type, with two shaped iron seats for passenger and pilot respectively, placed tandem, in its fore part, the passenger's seat being slightly higher than, and to the rear of, that of the pilot. Beneath the centre section are situated the main running wheels, which are of the light car type. Should these run into a furrow or ditch, the weight of the machine is immediately taken by the central skid, which measures 14ft. in length, and which projects 7ft. in front and rear of the main axle. There are two smaller wheels mounted at the front tip of the skid, one of which will be seen in the annexed engraving, the other having yet to be affixed. These are intended to aid the pilot in landing or upon leaving rough ground, in addition to the wheels placed at the tips of the wings above referred to.

Mr. Cody's biplane is fitted with a 60 horse-power four-cylinder "Green" motor, which is a vertical engine of all-British manufacture, possessing overhead valves and copper water jackets. The latter are pressed-on over a rubber ring, which is then vulcanised so as to make a perfect joint. The weight of the engine is approximately 4¾ lb. per horse-power, the diameter of the cylinders being 140 mm., and the length of stroke 146 mm. The camshaft is placed overhead, and is driven by a combination of worm and bevel pinions. It is easily movable in order to give access to the valves, which have a very good arrangement for preventing the heads from falling into the cylinder in the event of a stem breaking. The oil pump and magneto are also driven by steep-pitched worms. The engine has a dual ignition, and one of the main features of the success claimed for it is the improved method of lubrication introduced by Mr. Cody. On the exhaust side each cylinder has five auxiliary exhaust port-holes, which minimise the chances of overheating to a great extent. The engine is controlled by the pilot's right hand, and the direction of the aeroplane is attended to by the pilot's left hand, except in the case of sharp turning movements, when the right hand is also employed at the wheel. The only foot control is that of an accelerating throttle, which is very seldom used. The engine possesses no speed gearing, and there is no clutch between it and the propeller, starting being effected by giving the propeller a sharp turn round. An engraving and brief description of the Green aero engine was given in THE ENGINEER of March 18th, 1910, on page 271.

The oil fuel is stored in the sump or lower half of the crank case, and the capacity of the tank is 12 gallons. The radiators are a combination of the Zimmermann and spiral tube types, and are arranged so that the pilot and passenger receive the full benefit of the warm air after it has passed through the radiators, a great boon in cold weather and not amiss even in summer when flying high.

The new machine possesses what is believed to be the largest propeller of any aeroplane in the world. It was built under the inventor's supervision in the workshops of his flying school on Laffan's Plain, Aldershot. Its length overall is 11ft. 6in., or nearly 3ft. longer than the next largest propeller of this kind which has been made. It is constructed of silver spruce in five pieces, each of which is 1¾in. in thickness, laminated and glued together, giving a total thickness of 8¾in. The propeller is carved away at the boss in order that a large blade should be possible. Two-thirds of the blade from the tip to the boss is covered with heavy silk, put on with varnish as an adhesive. A steel boss is also mounted within the wooden boss, and this is keyed to the tapered end of the propeller shaft. A chain drive is effected from the crank shaft of the engine to the propeller shaft overhead by means of a compound sprocket and chain. The propeller shaft is hollow and of 2in. outside diameter. The screw is mounted at the rear of the main body, about midway between the top and bottom main planes.

It is estimated that the new machine will carry 800 lb. in addition to its own weight, which is about ½ ton. It is worthy of mention that Mr Cody has effected a considerable reduction in the weight of his latest machine as compared with that of his original Army aeroplane, which weighed over 1 ton. The inventor has introduced into his new machine a novel device in connection with its wings, of which, however, further particulars are not as yet available; but he is of the opinion that when tested

it will be found that in this new departure will lie the ultimate solution to the problem of automatic balance.

The measurements of the new biplane are as follows:—

Weight without fuel or pilot	1120 lb.
Lifting surface (approximately)	750 square feet
Width	44ft.
Depth, fore and aft	34ft.
Height overall	12ft. 6in.
Gliding angle	1 in 7
Weight carried	800 lb.
Angle of ascent after 100 yards run on level ground	1 in 6 for 50 yards 1 in 9 for next 100 yards 1 in 35 for next mile

ROYAL COMMISSION ON COAST EROSION.

No. I.

THE third and final report—Volume III., Part I.—of the Royal Commission appointed to inquire into and report on certain questions affecting coast erosion, the reclamation of tidal lands, and afforestation in the United Kingdom has just been issued as a Blue-book. The volume contains over 170 pages, and is accompanied by numerous drawings. The original warrant for the constitution of the Commission was issued in July, 1906, and the terms of reference under it were as follows:—

To inquire and report:

(*a*) As to the encroachment of the sea on various parts of the coast of the United Kingdom, and the damage which has been or is likely to be caused thereby; and what measures are desirable for the prevention of such damage.

(*b*) Whether any further powers should be conferred upon local authorities and owners of property with a view to the adoption of effective and systematic schemes for the protection of the coast and the banks of tidal rivers.

(*c*) Whether any alteration of the law is desirable as regards the management and control of the foreshore, and

(*d*) Whether further facilities should be given for the reclamation of tidal lands.

The following reference was added under a further warrant issued in March, 1908:—

(*e*) Whether, in connection with reclaimed lands or otherwise, it is desirable to make an experiment in afforestation as a means of increasing employment during periods of depression in the labour market, and if so, by what authority and under what conditions such experiment should be conducted.

We have dealt with the preceding volumes published by the Commissioners when they appeared, and there is no need to refer to them further in the present instance. In addition to taking evidence and making inspections in the United Kingdom and Ireland the Commissioners visited certain portions of the coast line of Holland and Belgium. Much valuable information regarding works of sea defence and reclamation, not only in Holland and Belgium, but also in France, Germany, and Denmark, was also acquired, and the Commissioners now find themselves in a position to make their final report on the matters referred to them. We may say that the question of afforestation was fully dealt with in the second Blue-book issued, which was dated January 4th, 1909.

The present volume is divided into seven parts. Part I. deals with physiographical and geological considerations affecting the coast line; in Part II. the Commissioners endeavour to form a general estimate of the extent of the erosion, accretion, and artificial reclamation which has occurred on the coasts and in the tidal rivers of the United Kingdom in recent years; Part III. treats of engineering questions, and takes into consideration various types of works which have been constructed for the purpose of defending the coasts of the United Kingdom against encroachment of the sea; Part IV. is confined to questions relating to central and local administration of the foreshore in the interests of the public, and of the coast line in the interests of sea defence; in Part V. the Commissioners reply to the question as to whether further facilities should be given for the reclamation of tidal lands, and consider whether the reclamation of such lands would afford a means of alleviating unemployment; Part VI. is devoted to consideration of the question of whether or not there is an obligation on the Crown to defend the coasts from inroads of the sea; while Part VII. contains a summary of the principal conclusions arrived at and recommendations made.

It will be impossible for us to give even in outline the contents of the various parts into which the report is divided; nor shall we attempt to do so. We shall content ourselves with referring to the points which appear to us to constitute the salient features of the report. Attention is first of all directed to changes of relative levels of land and sea, and it is shown that both emergence and submergence of land have taken place in late geologic times. Sometimes both movements have occurred at the same spot. At the present moment there does not appear to be any clear evidence that movements leading either to submergence or to emergence of land in England or Wales are taking place, saving possibly on the coasts of Northumberland and Durham. Possibly some of this, at any rate, is due to mining operations, or to the falling in of roofs of caverns in the magnesian limestone districts. It is stated that in Scotland there are, according to Dr. Horne, the head of the Geological Survey in Scotland, no indications that movements of elevation or depression are now in progress, though in another part of the report we read that possibly there are some in the extreme North. In Ireland there does not appear to be any conclusive evidence that movement either up or down is in progress, saving, perhaps, to a slight extent in the South and West.

Considerable attention is devoted to the action of waves and tides, and also to the depths at which motion of the water is noticeable, and with regard to this point the Commissioners state that—"It is difficult from the evidence to place a limit to the depth at which materials are moved on the floor of the submerged continental platform by wave or current action, or both combined. To what depth the movement of detritus on the sea floor is really effective in producing abrasion is as yet an open question, and one on which further investigation is needed."

The characteristics of Foreshore and Beach Material is then dealt with, and the sources, travel, accretion or disappearance are discussed, and then some twenty pages are devoted to a general description of the geological features of the coast line. Commenting on the evidence obtained concerning erosion during the progress of their inquiry, the Commissioners point out that though much land has been lost by this cause in some places, great gains have occurred along other parts of the coast. These gains take the form of accumulations of shingle, sand, and alluvium. The shingle and sand do not yield land of much economic value, but they afford protection to low-lying areas behind. The alluvium, on the other hand, makes, in time, good agricultural land. It is interesting to note that the greatest gains of alluvial land in England, within historic times, have taken place on the East Coast, and that these in all probability more than balance the great losses from erosion along that coast. It is pointed out, however, that, whereas on the one hand the lapse of long periods of time is necessary to realise the amount of gain which goes on by the raising of salt-marshes to a higher level from the deposition of silt or mud, and its almost imperceptible conversion into valuable land, erosion, on the other hand, tends to be intermittent, and when it does take place large slices may be removed at one time, and so give an exaggerated idea of its relative importance. In short, the results of the wearing away of the land are summarised by the statement that, while considerable areas of agricultural land are lost, sea coast towns are injured and harbours tend to silt up, large areas of valuable agricultural land are gained, and these areas, on the average, are more valuable than those which are lost. Then, too, there are the low-lying lands, which receive protection from the accumulation of shingle and the formation of sand dunes. However, much of the accreted land has to be protected from inundation by artificial banks—a process which, naturally, costs money, and the Commissioners justly remark that, though such gains "must be taken into account when estimating the total increase or decrease of area in the kingdom as a whole," they "do not compensate the particular owner of property who suffers from loss of land due to erosion."

It is pointed out that since the natural protection of the major portion of the coast is afforded by shingle and sand which accumulate on the foreshore and form beach material, and as these are derived originally from the waste of the land, it follows that a certain amount of erosion must go on in order to feed the beach. The removal of beach material, the removal by quarrying operations of solid rock, or even large boulders, occurring between tide marks, or the dredging of gravel or sand from the sea bed below low-water line, which may cause injury by deepening the water close inshore or so bringing a heavier sea to bear upon the beach, are all deprecated. It is urged that the preservation of sand dunes is of great importance along certain parts of the coast, where they afford protection to low-lying areas behind, and care is recommended to encourage the growth of marrum and other grasses which help to bind the sand. Where drifting or blown sand occurs much may be done to check it by fostering such grasses. The flourishing plantations of pine trees on sand-hills along the Moray Firth suggest that such trees could be advantageously grown on sand in other areas, especially on the South and West Coasts of England. The process of natural accretion on alluvial flats may be hastened by the planting of such vegetation as "rice grass" (*spartina*), and in this way land may be reclaimed by entirely natural means.

Very little, continue the Commissioners, is known of some of the factors which may influence coast erosion. Systematic observations are desirable as to the changes which take place below the level of low water. The evidence relating to such questions as submarine erosion, the travel of matter in deep water, and the movements of outlying sandbank was, they add, scanty, vague, and often contradictory. The evidence of the geological witnesses pointed to the fact that the erosion at many places was aggravated by the erection of defences of the wrong type. This was often due to lack of knowledge of the geological conditions of the district. Small isolated attempts at protection fail where larger schemes, embracing a longer stretch of coast, would prove more effectual. The Commissioners close this portion of their report with the following remarks:—"There is urgent need that in any scheme for the exercise by a Central Authority of control over the foreshore there should be ample provision for the assistance of scientific experts to collate information on the matters dealt with . . . to secure systematic observations of the changes which are continually taking place on the coast lines of the United Kingdom, and to advise on all questions relating to the coast."

The second part of the report deals with the extent of erosion and accretion in recent years on the coasts and tidal rivers of the United Kingdom, and it comprises some 36 pages of text. It is far too detailed for us to attempt to compress, and we propose only to summarise the conclusions arrived at. First of all, it is thought that, as already stated, far more land has been gained by accretion and artificial reclamation in recent years than has been lost by erosion. This comparison, it is explained, however, is misleading, unless the following qualifications are borne in mind:—

(1) The gain has been almost entirely in tidal estuaries, and to a very great extent has been due to the deposition of sediment brought down by rivers from their drainage areas. The loss has been chiefly on the open coasts. The evidence before the Commissioners was not sufficient to enable them to make anything like an exact comparison between the extent of land lost by erosion and gained by accretion on those coasts.

(2) A comparison of the superficial areas alone takes no account of the value of the property lost and gained. While much that has been lost was serviceable land—in some cases even occupied by buildings—much of what has been gained requires a varying amount of time and expenditure before it can be converted into serviceable land.

(3) The areas within the estuaries where natural accretion may be expected to take place and which are capable of being reclaimed are limited, and no deduction can be made from past experience which would enable an estimate to be made of what the gain and loss in the future may be.

There has been serious loss in the recent past, but it is pointed out that it would have been far more serious if the extensive works constructed by local authorities, railway companies and others, at great cost, had not been executed. "Admitting," says the Commissioners, "that the loss on some parts of the coast is great, and calls for the adoption of more effective measures for its prevention, we think that, from a national point of view, the danger is by no means alarming, and that it may to a considerable extent be remedied. . . ."

In Part III. the Commissioners discuss the engineering works necessary to prevent coast erosion, first of all referring in general terms to some of the leading factors which come before the engineer in devising sea-protection works. The special dangers to be guarded against in the design and construction of sea walls are referred to, and it is urged that in nearly all cases the building of the wall should be associated with a series of groynes carried out simultaneously with the erection of the main work. With reference to curved face walls it is pointed out that unless a rock or non-erodable toe is available to justify the adoption of such a form, a wall having a battered or slightly inclined face would appear to be preferable. Various types of groynes are then discussed, and it is stated that in many cases on the coast of the United Kingdom groynes have been constructed of a greater height than was necessary to fulfil the required conditions, with the result that they have so unduly interfered with the travel of shingle as to lead to impoverishment of the beach to leeward, causing in many districts serious injury to the coast. Speaking generally, the Commissioners are of opinion that, although the piling of groynes should be carried well above high water when the works are constructed, planking should only be added from time to time as the beach accumulates, so that there may not be at any time an excessive height of solid structure above beach level. The exact height must depend on the special circumstances of the case. Similarly, adequate provision should be made to prevent under-run of beach material below the bottom of plank structures.

As regards the length of groynes the general trend of the evidence laid before the Commissioners pointed to the desirability of their extending as a rule from the wall, bank, or shore to be protected, to the vicinity of low water of spring tides, if not even further out than that. To be of maximum efficiency groynes should be placed a distance apart about equal to their length. No general rule is laid down as to the direction of groynes, but it would appear that a direction at right angles to the shore, or preferably in many cases pointing slightly to windward, would prove, on the whole, to be the most effectual.

After reviewing the life and cost of groynes, both as regards construction and maintenance, the Commissioners again lay stress on the necessity before any works are commenced, of making a thorough and careful inquiry regarding the physical characteristics appertaining to each particular case.

With regard to the foreshore works on the coast of Holland and Belgium, which were examined by a committee of the Commission, it is explained that although these are of extreme interest and attended with considerable success, while some are of great magnitude and importance, they do not, in the judgment of the Commissioners, afford examples to be followed as affecting the sea defences of the United Kingdom. The principal conditions with which these works have to conform, namely, a low, flat foreshore, consisting entirely of sand, are wholly different from those generally associated with sea-defence works in this country. Moreover, the committee felt that works such as they examined would entail a larger relative expenditure than would be justified in corresponding undertakings in this country.

The Commissioners have come to the conclusion that the cost of protecting purely agricultural land, which is subject to erosion must, of necessity, under the conditions which usually prevail in this country, be considerably in excess of the value of such land, and that it follows that protection under such conditions is only justified if the works lead to the preservation from inundation of areas of low-lying land of considerable extent. There is another point which they consider has been clearly defined, and that is that regulation by a central authority would appear to be necessary, in the public interest, with regard to the construction of all defence works on the shores of the United Kingdom, so that adjoining tracts of coast may not be injured by works put up to protect a specific place. To this authority should be reported such changes as may be noted in the configuration of submerged or outlying sand banks, as also any information tending to throw light on the question of submarine erosion as affecting the landward approach of the sea, together with any data which may be available from time to time with respect to the movement or travel of material in deep water.

A PROPOSAL will be laid before the members of the Aëronautical Society to reconsitute the society by the institution of the following five grades of membership, viz., ordinary members, associate members, fellows, associate fellows, and students, the last three categories being reserved for persons engaged in technical work connected with aëronautics, while the first two are open to all who are interested in the work of the society.

OBITUARY.

EDWARD SNOWBALL.

IT is with great regret that we have to record the death of Mr. Edward Snowball, for many years chief draughtsman at Hyde Park Locomotive Works, Glasgow.

To many engineers, acting and retired, the intimation of the death of Mr. Snowball will recall the long and useful career of one whose ability and sterling worth never failed to command attention and esteem.

Practically coincident in time and place with the birth of the modern locomotive, as exemplified in the "Rocket," Mr. Snowball was born on the 25th January, 1830, at White House, Capheaton, Northumberland. His education was completed under Dr. Bruce, and his practical engineering training was also acquired in Newcastle, at the works of Robert Stephenson and Co. When he entered the works of Messrs. Stephenson as a premium apprentice he was 16 years of age, and before completing his apprenticeship he made, as it now seems, the very notable achievement of becoming chief draughtsman to that firm. From 1858 to 1863 he acted as locomotive superintendent of the then Scinde Railway in India. Returning from the East in the latter year for a short holiday, demanded by considerations of health, he met Mr. James Reid, of the Hyde Park Locomotive Works,

EDWARD SNOWBALL

Glasgow, who at once secured his services for his firm as chief draughtsman, a position which he held for a period of 38 years—from the beginning of 1864 to the end of 1901—when he had to retire from active work on account mainly of failing sight.

In those early days, before standardisation of the locomotive was even thought of, Mr. Snowball was the adviser as to the best locomotive practice of the many important clients of the Hyde Park firm. Mr. Snowball's work may therefore be seen in every part of the world on locomotives and on machines for their production designed by Messrs. Neilson and Co., and afterwards Messrs. Neilson, Reid and Co. While he was methodical and exacting to a degree in his care that every detail should be properly and fully proportioned for the work it had to do, he was even more particular that the beauty of the part and of the outline of the locomotive itself should always be maintained or improved. He also insisted that every drawing issued to the workshops should be a clear and finished production. Mr. Snowball was a member of the Institution of Engineers and Shipbuilders in Scotland for 41 years, and, while of a rather retiring and unassuming disposition, was always deeply interested in the proceedings of that body.

MUNICIPAL ELECTRICAL ASSOCIATION CONVENTION.

No. I.

THE annual convention of the Incorporated Municipal Electrical Association, which is being held at Brighton this week, opened on Tuesday with the usual civic welcome. The attractions of a seaside resort have brought together a record attendance, and the social side is holding its own well. It is the second occasion upon which the Brighton Borough Electrical Engineer has been selected as president of the Association, Mr. Arthur Wright having occupied the position fifteen years ago. At that time the membership numbered 114 all told, and the total capital expenditure of the undertakings represented by that membership did not much exceed £3,000,000. The membership now amounts to 407, whilst the capital invested in plant and machinery directly under the control of municipal electric supply engineers has increased to more than £41,000,000.

Mr. John Christie, the present chief electrical engineer to the Brighton Corporation, in his presidential address, gave a history of the electric supply business in Brighton, and, naturally enough, referred to the maximum demand system of charging. After being the pioneers in this method of charging, and in spite of it being generally recognised by electrical engineers as the most equitable from the consumers' and suppliers' point of view, the Brighton Electricity Committee found themselves steadily losing good business by retaining it, and a flat rate was substituted. The result has been that a slightly higher average price per unit has been obtained. At the time the flat rate was introduced, existing consumers on the maximum demand system were allowed to continue, but the rate was slightly increased, and to-day about 20 per cent. of the consumers who elected to retain the old system get their supply cheaper than the flat rate.

After a few words upon the experience at Brighton in the development of a power load, Mr. Christie made an important pronouncement in view of the present controversy regarding municipal wiring powers. He regards it essential that all electric supply authorities should possess powers to sell and hire out motors, and heating and cooking apparatus, but not to carry out the necessary wiring. In Brighton such powers have been enjoyed since 1901, although wherever possible the work is allowed to go over to the contractors. On the wider question of municipal trading in wiring premises and supplying and selling electric light fittings, Mr. Christie confessed with candour that he was not in sympathy with municipalities doing this work except under exceptional circumstances. In his opinion the interests of the local wiring contractor are common with those of the supply authority, which can no more afford to ignore the existence of the *bond fide* wiring contractor than the latter can afford to take up an attitude hostile to the interests of the supply undertaking. By friendly co-operation he perceives that much unnecessary expense in the way of elaborate showrooms, canvassing, and publicity organisation could often be saved without detriment to the undertaking in any way. Without depreciating these useful adjuncts to obtaining new consumers, Mr. Christie expressed his conviction that in certain instances this so-called business-getting has been overdone. His sentiments on this matter are:—"By all means keep your wares well before the public eye; believe in them yourselves; do all you can to persuade others to believe in them; induce your committees to lay mains broadcast and of ample section wherever there is any reasonable prospect of business resulting; have a simple, easily understood tariff as cheap as circumstances will permit; and lastly, if possible, keep friendly with and assist the local contractor, and do not hamper him with harsh and unnecessary restrictions. Then business of the right sort will, I am sure, come along almost automatically and just as fast as is good for your undertakings."

The presidential address, which, according to the usual custom, was not discussed, was followed by a paper by Councillor Leese, J.P., chairman of the Electricity Committee of the Federated County Borough of Stoke-on-Trent, in which he dealt with the question of electricity supply viewed from the municipal committee's standpoint. The burden of this paper was the difficulties encountered in bringing the electric supply in the six townships, comprising the new county borough of Stoke-on-Trent, to some degrees of unification, having regard to possible future developments. The towns in question were Burslem, Fenton, Hanley, Longton, Stoke and Tunstall, and of these six, four owned electricity works. At Burslem, Longton and Stoke there are continuous current systems, but each differ in the supply pressure, whilst at Hanley there is a single-phase alternating current supply at three different voltages. In addition, the maximum demand during 1910 was only met with difficulty, so that it was obviously necessary to do something. After much anxious thought it was finally decided not to add to the small plants in the existing stations, but to construct a new central power station at Hanley, and to connect it by trunk mains with the four existing power stations. The first instalment of plant will consist of 3000 kilowatts. During heavy loads the local steam plant will assist the new power-house, whilst on light loads the whole of the supply can be taken in bulk from the latter. The scheme, by the way, has met with considerable criticism, the opposition at the recent Local Government Board inquiry concerning the loan of £60,000 being very strong.

The paper then dealt with a number of points upon which municipal councillors frequently have very vague and hazy ideas. A feature of the Act of Parliament constituting the new county borough of Stoke-on-Trent is a clause which prevents the Electricity Committee from making a profit and transferring it to the relief of rates. If any profits are made after meeting interest and sinking fund charges and depreciation, then the charges to consumers are to be reduced, and this aspect of municipal electric supply, of course, receives strong support from Councillor Leese. The necessity of handing over sums from profits in relief of rates he considers a serious handicap to the development of electric supply among the smaller classes of users, as it entails maintaining prices. On this point one of the arguments of the opposition to the present scheme is that as no profits are to be made for the relief of rates, no further loans should be raised on the security of the rates for the undertaking. Councillor Leese also deals with the difficulty which many councillors experience in realising that average price is not cost price, and that the supply of energy for power purposes at very low prices during long hours does not entail a loss to the undertaking. In portions of Stoke, manufacturers are being supplied at 0.5d. per unit, which covers the cost of generation, but does not allow for sinking fund and interest on mains. For such supplies the author thinks that the charge should be compounded of cost of generation added to the cost of distribution, which latter will vary according to the distance of the consumers from the works.

With regard to the commercial side of electricity supply, the Stoke Council generally is averse to the opening of showrooms, an opinion with which Councillor Leese disagrees, whilst he supports the views of Mr. Christie as to the value of co-operation between the undertaking and local wiring contractors. In Hanley some six years ago an attempt to work together was made, which has succeeded beyond anticipation. The contractors were given supply at 1d. per unit, all corporation wiring is done by them, and they are lent any apparatus required for demonstrations, whilst in special cases they are paid a commission. The obstacle to a rapid increase of the use of electricity for cooking and heating is the impossibility of obtaining reliable and substantial stoves at a reasonable price. The £5 ovens are flimsy articles, while if £10 or more is paid the hiring rate is much in excess of that of a gas stove. But the trouble would not appear to end here, for, as Councillor Leese truly points out, in very few areas are the mains large enough to take on a considerable number of ovens without trouble with the voltage, and the addition of necessary copper to the mains piles up the capital charge on the undertaking faster than the revenue from the class of business increases.

In conclusion, the author mentioned that one of the most puzzling things coming before an Electrical Committee was the question of tenders. Although when issuing tender forms the engineer had been most careful to see that every point was made clear, so that every firm tendering should be on an equal footing, the varying figures of the tenders were very often astounding. In a particular case which had been dealt with recently for two turbo-generators the prices varied from £8000 to £11,800. One of the most peculiar things one had to deal with was the fact that, although the tender form gave all the conditions couched in the simplest language, and the contractor had sent in a price for the particular article, there was nearly always a covering letter to the tender, which, while accepting the conditions laid down in the tender form, suggested modification of this, that, and the other, which, if agreed to, would sometimes alter the whole construction of the article in question.

The discussion was noteworthy for a large number of councillors and engineers strongly protesting against municipal electricity undertakings transferring any portion of their profits to the relief of rates. Councillor Crowther, of Sheffield, Baillie Willock, of Glasgow, Mr. S. E. Fedden, of Sheffield, Alderman G. Pearson, of Bristol, Alderman Good, of Maidenhead, and Councillor Smith, of Glasgow, all took this line, the voice in the wilderness being that of Alderman Smith, of Liverpool, who, in advocating giving the rates the benefit of any profits, incidentally remarked that all street lighting should be done by gas, as it was cheaper and the illumination more even. Needless to say, this latter remark brought down loud shouts of disapproval upon his offending head. A new aspect of the policy of dealing with municipal trading profits was brought out, viz., the gradually decreasing terms which the Local Government Board is allowing for loans for electrical machinery. Alderman Pearson, of Bristol, told the members that they need not worry about the manner of disposing of their profits, as the periods for repayment of loans were getting so short, and the yearly repayments and interest correspondingly so large, that they would have very little profit to dispose of.

Electrical contractors came in for some rough handling, and it is quite clear that, despite the conference between the two associations last year and the appointment of a Standing Committee to deal with any matters that may arise from time to time, the membership of the Municipal Electrical Association generally is not satisfied with the position. In the discussion on Mr. Beauchamp's paper which followed the matter was again raised, and Mr. Vignoles, of Grimsby, urged the Association to promote a Wiring Bill.

The question of tenders and covering letters was touched upon, and Mr. Fedden, of Sheffield, said he regarded many such letters as sharp practice, at the same time appealing to contractors to send in straight tenders. On the other hand, other speakers pointed out that it was a matter that could be unduly magnified, for electrical committees and engineers were quite free to ignore such letters.

Mr. J. W. Beauchamp, borough electrical engineer at Tunbridge Wells, followed with a paper on "Modern Wiring Practice," in which he drew attention to the features of modern wiring practice and regulations in so far as they influenced the cost of small installation work. The supply of electrical energy to small premises he regards as one of the leading problems which electrical engineers have to solve, and a suitably designed system of wiring would do much to assist in the solution. In a brief analysis of the published regulations of a number of British and foreign authorities controlling or advising upon electrical work, he showed that a great divergence exists in their requirements, and suggested that even after allowing for climatic differences and local conditions, the cost of the wiring must be affected considerably by the varying limits imposed. Of the cheaper wiring methods that have been introduced, the most important appeared to be the re-introduction of the concentric principle in the form of the "Stannos" wiring system. Where it is possible to work on the surface of a building and use concentric conductors with the outer or return sheath earthed, a saving of 10 to 15 per cent. over slip joint conduit wiring can be secured by means of it in the hands of men accustomed to its use. Its chief disadvantages are set out in the paper as follows:—The multiplication of mechanical joints or points where loose connections may occur; the difficulty of securing to plaster and composition walls and ceilings; comparatively feeble resistance to accidental damage; risk of loss of continuity and consequent sparking or pressure rise on the outer conductor in the event of loose contacts or breakage of sheathing. The great value of this material lies in the fact that faults quickly develop into short circuits and put the bad section out of use, whilst repairs are easily carried out. In addition, all the simplicity and advantages of a single-pole system are secured. There would appear to be a field for a flexible wiring in connection with heating circuits, a heavy armoured and fairly flexible cord to carry up to 10 ampères without overheating, and provided with good plug terminal fittings and fuses of the cartridge type. Dealing with the new Institution of Electrical Engineers' wiring rules, Mr. Beauchamp referred to the new values which have been determined by experiment for the carrying capacity of cables. Although these new limits are only about 60 per cent. of the values allowed by the Verband Deutscher Elektrotechniker, they represented a great practical advance, and should reduce wiring costs, whilst allowing a good factor of safety against an increase in loading, which might take place after an installation had been put into service.

General concurrence with the author's views as to undue restriction by wiring rules was shown in the discussion, cases being quoted indicating that sooner or later the ideals aimed at by them will have to be dropped. Mr. Fedden, of Sheffield, showed how after a contractor had carefully finished an installation and left it fully in accordance with the Institution rules, the householder himself subsequently made additions which immediately put the installations beyond the rules. A keen desire was evidenced for further relaxation of the rules which will allow of cheaper construction. At Ipswich and Grimsby a little has been done in this direction already, for houses of a rental value of only £10 and £15 per annum have been dealt with by boring holes through the joists and running the wires down the walls in tubes. It is estimated that good-class wiring can be carried out in this manner for 4s. or 5s. per point. Complaint was made of the high cost of Stannos surface wiring, and the hint was thrown out that the price would have to be reduced by 50 per cent. before it could be made extensive use of.

Various opinions were expressed as to the use of low-

voltage wiring and lamps in conjunction with voltage reducers. On the one hand, at Sheffield the number of high-voltage lamps sold last year was larger than ever, compared with the number of low-voltage lamps; yet advantages accrue, on the other hand, in the greater safety from fire, whilst it is also cheaper where good work is put in. Similarly, opinions differed as to the necessity for earthing private house wiring installations.

Mr. F. Ayton, the electrical engineer to the Ipswich Corporation, suggested that the Engineering Standards Committee should have its attention drawn to the necessity for standardising switches, wall plugs, and ceiling roses. At present no two makes have the holes in precisely the same position, and to replace any of these accessories on a consumer's premises very often involved a good deal of irritating trouble and delay.

The Association met in Portsmouth on Wednesday and in Brighton on Thursday and Friday.

THE PAST, PRESENT AND FUTURE OF THE GOLD MINING INDUSTRY OF THE WITWATERSRAND, TRANSVAAL.*

By FREDERICK HENRY HATCH, Ph.D., M. Inst. C.E.

THE growth of the Witwatersrand goldfield was at first slow. Some of the earliest workers believed that the auriferous gravel, exposed in shallow open workings, was a superficial deposit of the nature of the alluvial "placers" of California and Australia. The true character of the conglomerate beds was, however, soon realised by those who were fortunate enough to possess some geological knowledge, and by 1887 stamp mills were in operation, the output from the Witwatersrand mines for that year being £81,045, and from then onward the progress has been rapid.

Down to the permanent water level, at a vertical depth varying from 200ft. to 300ft., the conglomerate beds were "free milling," that is to say, the iron pyrites, with which the gold is intimately associated, had been destroyed by oxidation, thus setting free the gold. Below the water table the colour of the rock changes from red to blue, the ore becomes pyritic, and the gold is no longer so amenable to recovery by amalgamation as is the case with the oxidised ore. This was the first difficulty that had to be overcome. Up to the year 1890 the treatment of the Rand ore had consisted of crushing in stamp mills, and the recovery of 50 to 60 per cent. of the gold, by amalgamation on mercury-coated copper plates. Usually the pulp leaving the amalgamating plates was also run over blanket strakes, with the object of retaining the rich "black sands," *i.e.*, iron ores produced by the oxidation of pyrites, and in some cases Frue-vanners were in use, the resulting concentrates being sold for treatment to the chlorination customs works. But the tailings received no further treatment; they were considered to be valueless, and, where the ground permitted it, were allowed to flow away.

The cyanide process.—But with the successful introduction of the cyanide process in 1890 dissipated, a new era in the history of Rand gold mining began, and it is no exaggeration to say that the great success of the Witwatersrand gold industry is a direct result of its introduction. For the majority of the mines, the gold won by this process represents the difference between profit and loss; and without it the profitable working of the vast quantity of low-grade banket now being mined on the Rand would be impossible.

The treatment of the slimes, which for some time after the introduction of the cyanide process had remained a waste product, was the problem which next engaged the attention of the Rand metallurgists. In the year 1894 experiments were made independently by Mr. Charles Butters, Assoc. Inst. C.E., on accumulated slimes at the Robinson mine, and by Mr. J. R. Williams at the Crown Reef mine, with such success that thereafter slime treatment became general. Briefly, the process consisted in causing the slime overflowing from the sand-collectors to settle, by the addition of lime; and the subsequent removal of the bulk of the water by decantation. The concentrated slime, so obtained, was then agitated with cyanide solution, which was ultimately drawn off by decantation.

In the most modern plants, the separation of sand and slime in a mill product is effected by feeding the mill pulp into a cone-shaped collector or diaphragm cone, which differs from previous classifiers in being run nearly filled with settled solids, instead of fluid pulp; the sand is drawn off as a thickened pulp from the bottom, while the slime flows over at the periphery. The sand, after passing through a secondary washing cone, which it leaves as an eminently leachable product with less than 1 per cent. of slime and about 30 per cent. of moisture, is freed from most of its remaining water on a Caldecott filter table, which is a slowly rotating horizontal vacuum filter. After almost completing a journey round the table, the sand, containing less than 12 per cent. moisture, is scraped off by a fixed inclined plough and falls into a launder, where it mixes with a stream of cyanide solution and is raised by a sludge pump to a vat already filled with solution. It is fed in by a Butters' distributor, the overflow being returned to the launder to complete the circuit. By this continuous method of sand collection the solution of the gold is commenced within half an hour of the crushing of the ore. The treatment is either completed in the collecting vat, or the charge is transferred to a second vat for final treatment. The process is accelerated, and assisted, by the use of the vacuum pump, by means of which the moisture, remaining in the sand after each draining, can be reduced to 9 per cent.

As to the slimes, their treatment has been much facilitated by the recent introduction of air agitation tanks and vacuum filters, which enable the enriched cyanide solution to be rapidly drawn off from the slime residue and sent as a clear liquid to the extractor-boxes.

The precipitation of the gold was effected in the original MacArthur-Forrest process by zinc shavings, and this method is still preferred, I believe, for the rich solutions, but for weak solutions, such as are obtained in the treatment of slimes, the Merrill patent, in which zinc dust is employed as a precipitant, is considered to be superior to the lead zinc couple, and this method is now being used at the Village Deep, and will be adopted by the Modder B, Brakpan, and other mines.

* The Institution of Civil Engineers.—The "James Forrest" Lecture, 1911. Abstracted.

Recent innovations in milling.—One important result of the perfection of the slimes-treatment process has been the introduction of fine grinding in tube mills, with consequent increased extraction and shortened treatment period. Further, the adoption of tube mills has modified the function of the stamp mill. The stamp mill, which formerly was not only the sole means employed for the comminution of the ore (excepting, of course, a preliminary reduction in jaw breakers), but also performed the duties of an amalgamating machine by the introduction of mercury into the mortar-boxes, is now, in most modern practice, restricted to a single stage in a continuous series of crushing operations. The researches of Caldecott and other members of the Mines Trials Committee have shown that the maximum diameter permissible for the battery feed is 1⅜in., and that tube mills are most efficient when fed with ore discharged through a nine-mesh battery screen having apertures of 0.27in., or say ¼in. The effective range of the stamp mill is, therefore, from 1⅜in. to ¼in.

In the newest plants the amalgamating tables are assembled together with the precipitating boxes for the cyanide solution, in a separate building—known as the reduction house—to which the tube mill pulp and the enriched cyanide solutions are conducted. In this building the gold is won, away from grease and oil, and under conditions which render amalgam-stealing—so serious a source of leakage in the past—practically impossible. Furthermore, the running time is increased, since the stamps no longer have to be hung up while the plates are being dressed.

Concurrently with the limitation of the effective range of the stamp mill, the weight of individual stamps has been increased by lengthening the heads, until, with the 2000 lb. stamp of the new mill of the City Deep mine, the economic limit of the cam-lifted gravitation stamp appears to have been reached.

The capital charge of a modern reduction plant per ton milled is one-third of what it was fifteen years ago, and the total ore treatment cost is about 3s. 6d. per ton, the recovery being from 93 to 96 per cent., according to the grade of the ore. The stamp duty (or tonnage crushed per stamp in twenty-four hours), which twenty years ago, in the days of the 900 lb. stamp and fine mesh discharge screening, did not exceed 3 tons, has gradually grown to an average of 7.45 tons for the whole Rand in 1910; and recent experiments have shown that by crushing to an aperture of 0.284in. and by introducing an elimination screen to "by-pass" the fine material from the rock breakers direct to the tube mills, it can be raised to as much as 26 tons per stamp.

The charge is sometimes made that the Rand metallurgists are unduly conservative, and that they are averse to the introduction of new processes, which may even have been shown to be successful elsewhere. But this conservatism is justified; the scale of operations on the Rand is so enormous that even minor changes in existing practice cannot be risked, without prolonged investigation and actual trial, under regular working conditions, on the spot. The seriousness of even a small loss per ton, which might result from an unwise change of practice, is shown by the fact that on one of the largest plants a difference of one-tenth of 1 dwt. per ton is equivalent to £18,000 worth of gold per annum.

Before leaving this part of the subject I will give some details of one of the latest mills erected on the Rand which will serve to illustrate the methods employed for the mechanical handling of the ore at the surface. The City Deep mill is designed to handle 65,000 tons of ore per month, and is equipped with 200 2000 lb. stamps and nine 25ft. by 5½ft. tube mills, each unit of ten stamps being operated by a 50 horse-power motor, and each tube mill by a 100 horse-power motor. The ore from the mine, delivered at the shaft head in 5-ton skips, is divided into two classes by screening through grizzlies, the bars of which are set at about 21⅜in. apart. The fine material is conveyed by a 20in. belt direct to the main ore bin; the coarse is taken by four 36in. inclined sorting belts to the crushers, which are placed on the top of the main ore bin, each belt feeding three 12in. by 24in. jaw crushers. The return portion of each sorting belt receives the rejected "waste" and delivers it to a 20in. belt—common to the four sorting belts—which conveys it to the waste dump. The main ore bin, which has a capacity of 1000 tons, and is constructed in reinforced concrete, discharges through heavy doors, operated by compressed air, into 40-ton trucks for transport to the mill. The ore train is drawn by a 25-ton electric locomotive, operating, through overhead transmission, on the 2000-volt 50-cycle three-phase current furnished by the Power Company. The trucks are fitted with automatic discharge doors.

In the stamp battery the ore is crushed to pass a 10-mesh discharge screen. The resulting pulp, after elevation by a 12in. Robeson-Davidson sand pump, is classified in cones, and the coarse product delivered to the tube mills. The product from the tube mills, together with the overflow from the classifying cones, is conducted to amalgamating tables in the gold recovery house. In this house are also placed the extractor-boxes for the enriched cyanide solution, the clean-up machinery, and the refinery, so that all the operations connected with the recovery of the gold are performed in one building, under the immediate supervision of the ore reduction officer. The pulp from the amalgamating tables is again elevated by a Robeson pump, and classified, the sands being collected in six vats of reinforced concrete. A 24in. conveyor belt, running under the centre line of these vats, takes the sand, excavated from them by a Blaisdell excavator, elevates it, and delivers it, by means of a belt running at right angles, to the top of the sand leaching plant, which comprises two rows of six vats each. The sand is fed in by a Blaisdell distributor, and, after leaching, is discharged by a Blaisdell excavator through central chutes to two 24in. conveyor belts, one under each row of vats. A short cross-belt delivers it to a 24in. inclined belt, which conveys it to the residue dump. This belt is carried on a steel cantilever frame, the end of which is 100ft. above the surface of the ground. The slimes are collected in four conical-bottomed collectors, built in reinforced concrete. They are treated in two steel conical-bottomed air agitation vats, of 32ft. diameter by 38ft. deep, and washed in eight steel conical-bottomed wash vats, 70ft. in diameter by 16½ft. and 23½ft. deep.

In the plant just described, it will be observed that from the moment the ore is delivered at the shaft head, until the residues, containing only 5 per cent. of the original gold content, are finally deposited on the "dump," the various products are conveyed from point to point, either by water, moving under the influence of gravity supplemented by sludge pumps, or by purely mechanical appliances. In other words, native labour has been practically eliminated from the surface operations of the City Deep mine.

Native labour.—This completes my survey of the surface operations. I will now ask you to accompany me underground to study the economies in time and labour that have been effected in recent years by the introduction of mechanical appliances. The search after labour-saving devices has been forced on the mine owners by the fact that, in spite of a substantial growth, the supply of native labour has never equalled the demand, a position which has been accelerated by the recent repatriation of the Chinese. Shortly before the outbreak of the Boer War in 1899, the natives employed on the gold mines numbered 97,000. The number of natives employed on the gold mines at the end of April of this year was 194,328, which is the largest number of coloured labourers ever employed on the Witwatersrand mines, and it is estimated that another 70,000 will shortly be required.

Efforts are being made to attract the native to the mines by improving the conditions under which he lives both on and off shift. One important innovation has been the curtailment of night work. Thus, in the mines under the control of the Consolidated Gold Fields Company, only 7.4 per cent. of the total coloured labourers working underground at the end of 1910 were employed on night shift. Another step in the right direction has been the provision of shelters at the shaft head, and the erection of covered ways between the shaft head and the compound, for use in inclement weather. The "boys" come up from their work hot, tired, and dirty; the protection thus afforded them from the bitterly cold winds that blow through the winter months, and the warm shower bath that is now insisted on in many mines, will do much to mitigate the pneumonia scourge that used to be so prevalent among native miners on the Rand.

The dust problem.—Underground, efforts have been made to solve the dust problem. With few exceptions the Witwatersrand mines are dry mines, and the processes of machine-drilling, blasting, and shovelling consequently create and distribute through the air great quantities of fine dust. Fortunately, the gold mines enjoy an important distinction from coal mines in regard to this phenomenon, owing to the fact that the dust is non-inflammable, and therefore does not lead to explosions. But the inhalation of the dust-laden air causes a peculiar disease, known as miners' phthisis or silicosis, as it is also termed—a deadly complaint which is responsible for a high mortality among the white miners, and to a less degree among the native labourers. By the proper application of water at the point of origin, the formation of dust can, to a large extent, be prevented; but the chief difficulty, however, appears to be to get the men to use the dust arresters, and to water down the stopes and other working places after blasting. By better supervision and a stricter enforcement of regulations, such difficulties will doubtless be overcome; and, with the disappearance of this serious evil, the conditions under which the men work underground will be scarcely less healthy than on the surface.

Ventilation.—This brings me to the question of ventilation. In the early days on the Rand, and, indeed, up to quite recently, it has not been found necessary to employ any artificial system of ventilation, the numerous shafts and outlets to the surface of the outcrop mines having sufficed to maintain an ample supply of fresh air. But with deeper levels—the Village Deep mine is already working at a vertical depth of 4000ft.—fewer communications with the surface and an increased rock temperature artificial ventilation is destined to play an ever more and more important part in the future. Mr. Stuart Martin gives it, as his opinion, that it will be impossible to work the deep levels economically without carefully thought out schemes of ventilation; and that for the success of these it will be necessary to have shafts with small frictional resistance and large air space, and to carry the air current through special ventilating roads.

The ventilation problem has already been seriously attacked on the Rand, and already ventilating fans, varying in capacity from 50,000 cubic feet per minute, at 1in. water gauge, to 250,000 cubic feet, at 4in. water gauge, have been installed at the East Rand Proprietary mines, at the Simmer Deep, at the Village Deep, at the Langlaagte Royal Shaft of the Crown mines, and at several other mines of the Eckstein Rand mines group. In splitting the air current the numerous dykes of igneous rock that traverse the Witwatersrand mines in a north and south direction—*i.e.*, across the strike—can be made to serve as natural brattices, since they cut up the mines into air-tight compartments. The levels, which penetrate these dykes, must be permanently closed, or, if used for tramming purposes, closed by double swinging doors.

Underground transport.—I pass on now to the subject of underground transport. The ore broken in the stopes has, in the past, been trammed on light rails from the stoping-boxes to the loading station at the shaft, in four-wheeled trucks of from 12 to 16 cubic feet capacity, the motive power being hand labour. While the ore was being transported on every level, through tortuous and badly-graded roads of the customary small dimensions, scarcely any other method was possible.

Under the changed conditions now prevailing on the Rand, due to the enormously increased size of the properties brought about by recent amalgamations, and the consequent possibility of concentrating a large output on fewer main hoisting shafts than heretofore, the evolution of an entirely new system of underground transport is being accomplished. It is becoming recognised that the rock broken in the stopes can only be economically dealt with by handling it on a few main haulage-levels, situated at great intervals apart, and driven straight, from point to point, in the footwall of the reef. The rock mined above each haulage-level can be delivered through vertical or inclined passes, and should it be necessary to feed the haulage with rock mined below the level, such rock can be raised through inclined roads by mechanical haulage or electric hoists. These main haulage-roads—which, as already explained, are intended to serve also as the intake of the fresh-air current—can, on account of their economic importance, be constructed of large dimensions. They can also be carefully graded and equipped with heavy rails.

Endless rope haulage can only be used with advantage where the roads are straight; where there are many curves it is preferable to draw the ore trains either by petrol locomotives—as at the Langlagte Deep—or by electric locomotives—as at the Geduld mine. With the latter system some difficulty is experienced in completely insulating the electric current from the raw and careless native. The bold policy of driving these straight haulage roads in the footwall of the reef, before even the ore-body has been blocked out, such as is being carried into effect on the Crown, New Modderfontein

and Modder B. mines, is an interesting indication of the confidence of the Rand engineers in the relative permanence of the gold content of the banket formation, as compared with quartz veins. The big intervals at which the reef levels are now being driven is another indication of the same confidence.

Stope conveyors.—The handling of the broken rock in the stopes is, from an economic point of view, scarcely less important than its haulage on the levels. Everything depends on the angle of dip of the reef. In many of the outcrop mines of the Central Rand the high dip of the reef permitted the rock broken in the stopes to find its way by gravitation to the tramming level, where it was drawn off as required from the stope boxes; but with the dips of from 25 deg. to 30 deg. obtaining in most of the deep-level mines, the broken rock requires to be assisted down the stope-floors by shovelling or "lashing," as it is called in miner's parlance. Only in the extreme East Rand, where the reef lies very flat—dipping at from 8 deg. to 10 deg.—is it possible to fill the trucks at the stope-faces and to run them thence direct to the tramming levels. Hand-shovelling is uneconomical, and, moreover, is detrimental to health on account of the dust it raises. Consequently, several attempts have been made to substitute for it some conveyor system of handling the broken rock. Mr. E. J. Way, M. Inst. C E., has described a method employed by him at the New Kleinfontein mine, by which he effected a very large reduction in the number of unskilled labourers engaged in shovelling rock down the stopes. Mr. Way's stope-conveyors are shaking chutes consisting of iron plates, 18in. wide and 8ft. long, the whole chute varying in length, according to the state of development of the stope, from 32ft. to 224ft. They are suspended by short chains from the roof next to the working face of the stope, and are operated by one or more men, according to their length, who pull at ropes attached to the upper ends of the conveyors. Kept in motion by the jerks thus transmitted, the ore slides down the conveyors and is discharged at their lower ends into stope-boxes, or direct into trucks at the tramming level. Being easily dismantled, the conveyors can be taken down before and put up after each blast. When the working face has advanced about 6ft. they are hung in a new position close to the face of the stopes, a series of small holes being drilled in the roof to take the hook-bolts carrying the chains. Many of these shaking chutes are now in use on the Rand, and are now mostly hung from a rope stretched taut along the roof.

Machine drills.—In the past the use of machine drills for stoping had not been looked upon with much favour. For this there were several reasons, first, the machine used was the heavy drill employed for development work, and with this type it was impossible to work in narrow stopes without breaking a large amount of waste; secondly, the bands of barren quartzite, with which the payable conglomerate is often interstratified, suffered such pulverisation by reason of the large blasting charges used, that often it could not afterwards be eliminated by sorting; and thirdly, the large blasting charges were found to weaken the roof, so that a greater number of pillars had to be left for its support; that was the case with hand drilling. Only in wide stopes, on a large homogeneous reef with good walls, could these drills be used to economic advantage. The necessity for a good stoping drill for narrow reefs, however, has become more and more pressing with the extension of the mining industry, with which the supply of native labour for hand drilling has not kept pace. It may be taken as established that machine drilling in moderately narrow stopes costs no more, and perhaps even less, than hand drilling by natives. Hundreds of small drills—drilling a hole to take a $\frac{7}{8}$in. explosive—are already employed for stoping on the Rand, and their average duty is $\frac{3}{4}$ fathom per shift. To stope very narrow and low grade reefs hand labour has still to be used; but it is hoped that a drill, capable of doing even this class of work, will eventually be evolved.

Sand-filling.—I shall now direct your attention to another important problem which has recently forced itself on the notice of those responsible for the mining operations on the Rand. I refer to the support of the hanging wall. The removal of the gold-bearing conglomerate bed which, except for its somewhat steeper dip, may be compared to a coal seam, leaves an open space, which is not allowed to fall in, as in a coal mine worked on the long-wall retreating system, but is supported over enormous areas by pillars of unworked conglomerate in the stopes; by ribs left above and below drives; and by pillars left to ensure the safety of the shafts, supplemented in some cases by the stowing of waste rock. These methods have sufficed in the past to keep open the stopes and drives and to protect the shafts; but, owing to the robbing of the stope pillars in the outcrop mines, and more especially to the increased pressure of the superincumbent rock mass in the deep levels, serious movements of the hanging wall have lately been making themselves felt, crushing the pillars in the stopes, destroying the ribs above and below the drives, and in some cases even affecting the shaft pillars.

To arrest this untoward movement, which at one time threatened the loss of the main thoroughfares of some of the mines, a system of sand-filling has been adopted. By this system the abandoned stopes and other working places in the mines are filled with sand, taken from the residue dumps or run in direct from the current reduction operations. This method has been borrowed from the Silesian coalfield, where it has for many years been in successful operation, enabling a thick seam of coal to be safely mined under towns, villages, rivers, and main lines of railway.

The method employed, in the case of the old residue dumps, is to mix the sand with sufficient water to cause it to flow down pipes in the shafts and to be discharged in the stopes prepared for its reception. Where current sand residues are used, these are pumped as a pulp from the sand-treatment vats, and are thickened in cone classifiers before delivery underground. Underground the pulp is conducted by wooden launders to the stope to be filled. Barricades are used to keep the sand in place; but it drains well, and soon packs solid enough to bear the weight of a man. The effluent water is pumped back to the surface, and this charge is one of the chief items of expense. Another is the renewal of the pipes used to convey the sand down the shafts. The sand is extraordinarily abrasive, and the life of the pipes is very short. The cost of the process is, however, balanced to some extent by the increased ore reserves, due to the advantage of not having to leave pillars in the stopes, coupled with the saving of the cost of cutting them.

Electric transmission of power.—One of the most remarkable economic changes on the Rand is now being brought about by the concentration of the steaming plant at two or three centres, from which power is distributed to the mines by electric transmission, or in the form of compressed air. This has largely been the work of the Victoria Falls and Transvaal Power Company; although one or two of the mining groups—notably the Farrar and the Robinson—have established their own power stations. Electrically-transmitted power is rapidly supplanting independent steam power for mills, winders, sinking engines, underground hoists, pumps, &c., owing to the favourable rate at which it can be purchased from the power company. The price has been fixed by agreement at 0.561d. per unit until October, 1912, and thereafter at 0.525d.

A considerable economy will be effected by this centralisation of power generation, and the consequent reduction in the number of independent steaming plants. From the price per unit at which the Victoria Falls and Transvaal Company are supplying power, the cost of a horse-power per annum, utilised continuously day and night, can be calculated; it works out at £14. It is not so easy to arrive at the average cost of a horse-power year on the mines prior to electrification, but it is stated to have been £28. In any case, the saving due to the substitution of electric motive power for steam power is undoubted, and there is, moreover, the indirect advantage of greater flexibility and more perfect control.

The introduction of electric winders on the Rand has practically decided the long-debated question of winding f om great depths in favour of stage winding, as against a single lift. By the adoption of a large unit of hauling and a suitable arrangement of loading boxes, the loss due to the repeated handling of the ore can be reduced to a minimum.

Production statistics.—Having now touched on those features of the surface and underground equipment of the mines that have recently undergone, or are still undergoing, the greatest changes, I will endeavour to illustrate to you the present position of the industry, and the progress to be expected in the future, by a few statistics. Since the discovery of the Field in 1886 to the end of 1910 the Rand has milled 155 million tons of ore and produced gold to the value of £276,000,000, this being an average of 35.6s., or 8.4 dwt. of fine gold to the ton milled. During the same period dividends amounting to £72,416,550 have been distributed, equivalent to 9.3s. per ton milled. During 1910 gold to the value of close on £31,000,000 was produced by crushing 21,500,000 tons of ore; this is equivalent to an average yield of 28s. 6d., or 6.7 dwt. of fine gold per ton milled. The working costs averaged—from the returns of fifty-six companies—was 17s. 7d. per ton, giving an average profit of 10s. 9d. per ton milled.

Some few years ago, my friend, Mr. T. H. Leggett, and I set ourselves the task of estimating the production of gold to be expected from the Main Reef series, if worked down to a vertical depth of 6000ft. Up to that date—1902—the Rand had already produced gold to the value of £76,800,000; and we calculated that another £1,233,500,000 could be produced down to the depth stated. The average of the figures for gold recovery used in our estimate was 38s. to the ton. The actual recovery at the time averaged 42s. It has since fallen to 28s. 6d. But, on the other hand, large bodies of ore are now being worked that were then passed over as unprofitable. No doubt, to a large extent, the one factor cancels the other; so that, for the purposes of a rough estimate, as this must of necessity be, we may still make use of the sum total then arrived at.

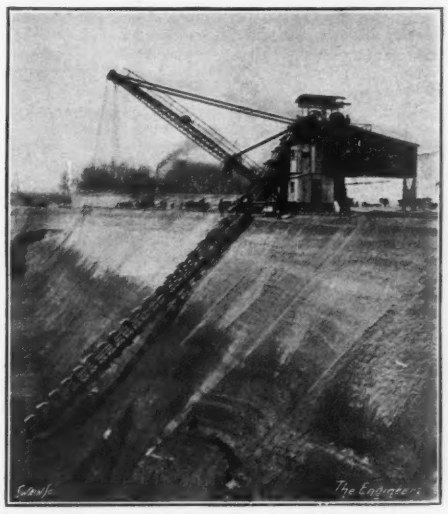
Between the years 1902 and 1911 the Rand has produced £187,000,000. Deducting this figure from the sum total, there remains £1,046,000,000, which, on the basis of an average output of £30,000,000 per annum, is equivalent to a life of thirty-five years, *i.e.*, down to a vertical depth of 6000ft. But, if at still greater depths the banket should contain sufficient gold to yield a profit, after deducting the cost of working—which, under the best conditions existing at the present time, is 12s. 6d., or about 3 dwts. of fine gold to the ton—we may rest assured that it will be worked. What then are the limiting factors? They are generally considered to be (1) the mechanical difficulty of raising the ore to the surface from such great depths, and (2) the effect of the temperature gradient. With regard to the mechanical question, the electrical transmission of power applied to stage-winding has so modified the mining engineer's conception of the depth from which deep hoisting is practicable, that it is now generally assumed that there are no mechanical difficulties that cannot be overcome if it pays to do so. In respect to the temperature question, Mr. Marriott's careful experiments have shown that the rise is only 1 deg. Fah. for every 208ft. of depth, and that the average rock temperature at 1000ft. is 68.7 deg. Fah. Figuring on these data, the rock temperature at 7000ft. would be only 97.5 deg. Fah., and with efficient ventilation the air temperature would of course be considerably lower. It follows, therefore, that for all practical purposes the whole question turns solely on the gold content, and what that may be at a vertical depth of 7000ft. or 8000ft. no one can tell. This much, however, may be said, the geological structure of the country clearly indicates the continuance of the conglomerate or banket beds to still greater depths than even 7000ft. or 8000ft., before the bottom of the great synclinal basin of the Witwatersrand is reached; and, beyond that point, the beds must still continue until they rise to form the southern lip of the basin, known to exist beyond the Vaal River.

EXCAVATOR FOR AN HUNGARIAN CEMENT WORKS.

AN excavator of a somewhat remarkable character and size has lately been put to work in the clay quarry of a cement works in Hungary. It is illustrated in the accompanying engraving, and its size will be appreciated when it is said that the bucket guide has a length of 125ft.

The clay beds are composed of a comparatively light material—in layers of more or less sandy and moist, but not sticky clay—which lies in 16 clearly defined horizontal strata, all of different chemical composition. The material was formerly quarried and mixed by manual labour, but some years ago it was determined to substitute mechanical methods. In order to keep the works supplied with material of a uniform nature, it was desirable to extract it from the beds—which have a combined depth of 66ft.—in one single clean cut instead of working at different levels. This could naturally only be done by an excavator of unusual dimensions, such as that now illustrated. It is at work at some considerable distance from the cement mill, and runs on a track about 920ft. long. The extracted material, as it is raised by the buckets, is delivered into two hoppers, and thence into trucks running on a chain railway for conveyance to the mill.

The frame of the excavator is built up of rolled sections and plates, and is stiffened with strong cross and diagonal bracings. The bucket chain is driven by an alternating current motor of 75 horse-power, working on a 500-volt circuit. The movements of the bucket chain, the travelling of the excavator and the raising and the lowering of the bucket guide are quite independent of each other, and can be brought about either simultaneously or successively. The buckets employed are made in one piece from pressed steel plates, with a removable cutting edge which can be easily sharpened or exchanged. The working angle of the excavator guide is



EXCAVATOR FOR A CEMENT QUARRY

47.5 deg.; the whole machine runs on a track with a gauge of about 10ft. The distance from the centre of the travelling track of the excavator to the centre of the chain railway is nearly 14ft. The projection of the counterweight is about 50ft., and the counterweight itself, which consists of stones, weighs 40 tons. The bucket guide, as already mentioned, has a length of 125ft., with a dredger depth of about 65ft. Pendulum feet are fitted on the rear side of the counterweight, which rest on the ground when the excavator guide is resting on the quarry side, and in this manner carry the main part of the counterweight.

This excavator was constructed by Adolf Bleichert and Co., of Leipzig, and in spite of its unusual size has, we are informed, proved réliable and successful in working.

INTERNATIONAL CONGRESS ON SANITARY DWELLINGS.

THE third International Congress on Sanitary Dwellings will be held at Dresden from 2nd to 7th of October, 1911. The aim and object of the Congress is the scientific advancement of hygiene and sanitation. Anyone either theoretically or practically interested in the problem of sanitary dwellings is eligible for membership. The Working Committee of the Congress reserves to itself, however, the right to exclude any person it may consider unsuitable. The membership subscription is 25 marks, and relatives of members may on payment of a subscription of 10 marks attend the conferences and functions of the Congress, but may not take part in the debates or vote, nor will they receive the printed reports. In addition to the other publications in connection with the Congress, each member will receive a copy of the report of the proceedings after the close of the Congress and the daily journal.

The preliminary work of the Congress has been entrusted to a Working Committee which is subdivided into a number of subcommittees. The Congress will be under the direction of a chairman, several vice-chairmen, a general secretary, and a treasurer. It is to be divided into nine sections as follows:—

Group A: General.—Sec. I.—Town planning (building, forms of country settlement, garden cities, width of streets, height of building). Sec. II.—Construction of buildings (planning, distribution of space, building material, foundations, basement, kitchens, lavatories, floors and ceilings, staircases, lifts and roofs). Sec. III.—Internal arrangements (lighting, heating, ventilation, furnishing). Sec. IV.—Sanitation (cleaning, removal of refuse, disinfection).

Group B: Dwelling-houses.—Sec. V.—Dwelling-houses in towns. Sec. VI.—Dwelling-houses in the country.

Group C: Special kinds of dwellings.—Sec. VII.—School buildings, boarding schools, prisons, hotels, lodging-houses, hospitals, convalescent homes, baths, churches, theatres and other public buildings. Sec. VIII.—Work rooms and workshops, means of communication and transit (railways, tramways, ships, vehicles, &c.)

Group D.—Sec. IX.—Legislation, executive, statistics, &c.

Each section will have its own chairman, who will be assisted by a vice-chairman and two secretaries. The conferences of the Congress will consist of general assemblies and sectional meetings. Two or more single sections may also hold combined meetings. The official languages used are to be German, English and French. Half an hour at most will be allowed for the reading of any report or supplementary reporter contribution. Every speaker in discussions will be allowed five minutes. The meeting shall decide whether anyone desiring to do so shall be allowed to speak longer, or more than twice on the same subject.

Notice of papers to be read and demonstrations should be sent to the general secretary of the Congress, Stadtrat Dr. med Hopf, Zimmer 156, neues Rathaus, Dresden, and the reports and papers must be delivered to him two months before the opening of the Congress to allow of their being translated and forwarded to the members. A daily journal will be published while the Congress lasts, and it will contain all requisite notices for the members, and more particularly the place, time and agenda of the general assemblies and the sectional meetings, the inspections, entertainments, &c.

THE ROYAL AGRICULTURAL SHOW.

No. I.

WHEN the Royal Agricultural Society decided to hold its 1911 Show at Norwich the decision was largely influenced by the fact that King Edward VII.—who was so deeply interested in agricultural affairs—had his country home in the county of Norfolk. It certainly was not foreseen that the life of the great Peacemaker would have terminated, and that the festivities in connection with the Coronation of his son, King George V., would practically coincide with the dates of the Show. Such, however, is the irony of fate. This is the third time that the Royal Agricultural Show has been held in Norwich. The first occasion was sixty two years ago, when the total number of stand holders was 145; the second was in 1886. It is interesting to note that quite a large proportion of the implement making firms represented in 1849 are still in existence, in spite of foreign competition. For instance, amongst the exhibitors in 1849 we find such familiar names as Charles Burrell, James Woods, Richard Garrett, Clayton and Shuttleworth, William Crosskill, Richmond and Chandler, Edward Bentall, Howard and Sons, Richard Hornsby, Robert Maynard, and W. N. Nicholson. The exhibits included eighteen steam engines, of which Clayton and Shuttleworth had three, Richard Garrett two, and thirteen other firms had one engine each. The engines were catalogued as from 4 to 9 horse-power, and were nearly all "portables." They had all tubular boilers, and were specially designed for driving thrashing machines. There was one road locomotive shown by Ransomes and May and made by E. B. Wilson and Co., Leeds. Thrashing machines were fairly common, and there were a few haymaking machines. These few facts will serve to remind us that although progress in agricultural machinery design has been great of recent years, there were ingenious minds at work on the subject sixty years ago.

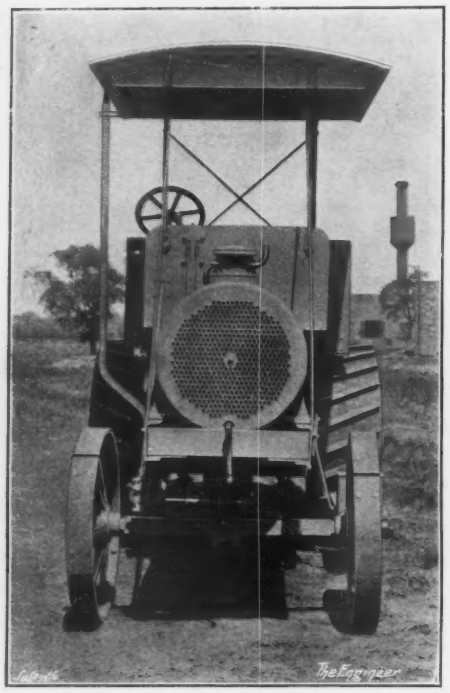


Fig. 1—DAIMLER 30 HORSE-POWER TRACTOR

Although it cannot claim to be in the midst of a vast population, Norwich is an important centre of the great agricultural industry. Wheat and barley are the chief cereal crops of Norfolk, and the county possesses a native breed of cattle called "Red Polls." Horse breeding is also a local industry. Norwich possesses numerous attractions for those interested in mediæval history. Its cathedral is one of the most beautiful buildings of the kind in the kingdom, and has been in existence eleven centuries. This year the show is being held on the same site as that chosen for the 1886 Exhibition. It forms part of the beautiful estate of Mr. Russell Colman, and 108 acres are taken up by the exhibits. There are 6690ft. of shedding in the implement yard, of which 3095ft. are for machinery, and there are 457 stands in this section, compared with 454 in 1910, 437 in 1909, 389 in 1908, 417 in 1907, and 424 in 1906. The latter is the date of the first of the new series of county shows. Although there are a few noteworthy absentees this year, a perusal of the catalogue shows that the list is, as usual, fairly representative. Quite the most noteworthy feature of the heavy engineering section is the increasing numbers of firms which are showing tractors propelled by internal combustion engines, and we propose to say something about the chief characteristics of the new departures in this line first. An opening for this class of machine has been found in the Colonies, where water suitable for steam-raising purposes is frequently difficult to obtain, and where coal for fuel is dear. Messrs. Marshall and Sons were among the pioneers in this branch of engineering, and the oil tractors shown by them at Norwich are built on massive lines. This firm, like most others, adopts the vertical type of oil engine, with four cylinders, giving 80 to 90 brake horse-power, and drives through stout spur gearing on to a spur ring on the road wheels, but there are other firms who make machines for this class of work with much smaller power, and such as will suit the purposes and purses of the small tenant farmer. In this category are to be included the firms of Saunderson and Gifkins, Bedford, and Petters, of Yeovil.

The Daimler Company, of Coventry, is exhibiting for the first time at these shows two types of petrol tractors and one of the well-known Renard road trains. The last mentioned is familiar to our readers. The train shown is for carrying coal, and is capable of dealing with 21 tons. It has side tipping wagons, of special construction, each of which can be easily attached and detached. The agricultural machines are built in two sizes, both of which we illustrate. Figs. 1 and 2 and Fig. 8, page 672, show the 30 horse power tractor, and Figs. 3, 4, and 9 give a good idea of the design and constructional features of the 100 horse-power tractor. It will be noted that the machines offer a striking contrast to many now on the market. The sleeve valve engine has been adopted in both vehicles. In the 100 horse-power machine the engine is placed in the rear of the tractor behind the driving wheels. The method of transmitting the power to the road wheels is somewhat novel. The engine fly-wheel contains a metal-to-metal clutch of the cone type, and operated by a pedal on the driver's platform. In front of this clutch is a double universal joint to allow of flexure of the frame on rough roads, and the removal of the engine if necessary. The universal coupling leads to the gear-box, which provides a second forward speed and a reverse, in addition to the forward direct drive. The direct drive gives a road speed of about four miles per hour, while the low gear may be chiefly used for ploughing at, say, 2¼ miles per hour. In front of the change-speed gear-box a worm gear-box transmits power at a reduced speed to the transverse shaft, which has on its ends small spur wheels. The latter mesh with large spur rings on the road wheels. Inside the driven worm wheel is placed the differential gear, which can be put out of action if desired by a lever, as when the tractor is climbing steep hills or travelling over soft ground, in which case the differential gear is locked. The forward portion of the tractor frame is occupied by the fuel and water tanks and radiator. The fuel tank is placed right in front, and behind this is the chimney, by which the exhaust gases are blown into the atmosphere, serving also to induce a draught through the radiator, together with a fan. The control gear is placed on the dashboard in front of the driver, and consists of a side lever, clutch pedal, and throttle lever. The weight of the large tractor ready for use is about 11 tons, and we are informed that a draw-bar pull of 12,000 lb. can be obtained at ploughing speed.

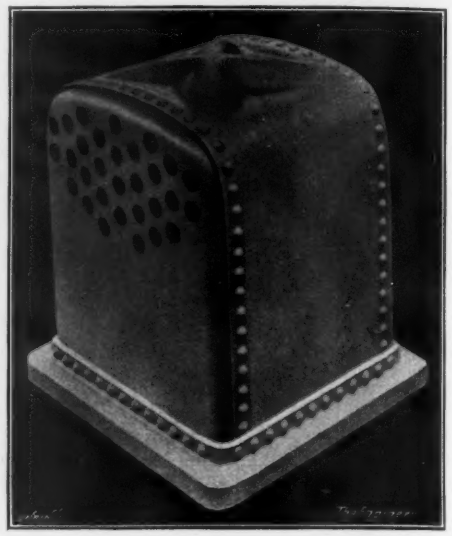


Fig. 5—FIRE-BOX OF MARSHALL'S ENGINE

In the 30 horse-power tractor the engine, a four-cylinder sleeve valve motor, is situated in front of the vehicle and behind a circular radiator. The drive is transmitted from the engine through a leather-faced cone clutch to the gear-box, which is bolted directly to the worm case. The gear wheels give three speeds forward and reverse. The forward road speeds are 2¼, 4, and 7 miles per hour. The selection of gears is effected by one lever. A shaft parallel to the primary shaft and driven from it by spur gearing is placed at the rear of the tractor and carries a pulley for driving thrashing or other machinery. This shaft can be thrown in or out of action by the gear-operating lever, which at the same time locks all gears in their neutral position, thus ensuring that the tractor shall not move while the pulley is in use. To propel the vehicle a case-hardened steel worm engages at the top with a phosphor bronze worm wheel which encircles the bevel differential gear. The latter can be locked for hill-climbing. The final drive of the road wheels is transmitted by spur pinions on the cross shafts meshing with spur rings bolted to the wheels. The frame is in two parts and consists of a main frame carrying the engine, fuel tank, and body, and to which is attached the front axle. A second frame underneath the main frame, but attached to it at the front by links, carries the worm case and rear axle. Guide blocks pressed on the axle work in horn blocks bolted to the main frame. These rest on coiled springs suspended from the axle by links. The lubrication of the engine is automatic, being effected by a multiple plunger pump driven by the engine and supplying oil to a trough beneath each big end. Ignition is by the Bosch dual system.

One of the features of chief interest on Marshall, Sons and Co.'s stand is the high-pressure portable engine of which we give an illustration, Fig. 6. This is a single-cylinder engine designed with the object of securing the utmost economy in fuel consumption. It works with

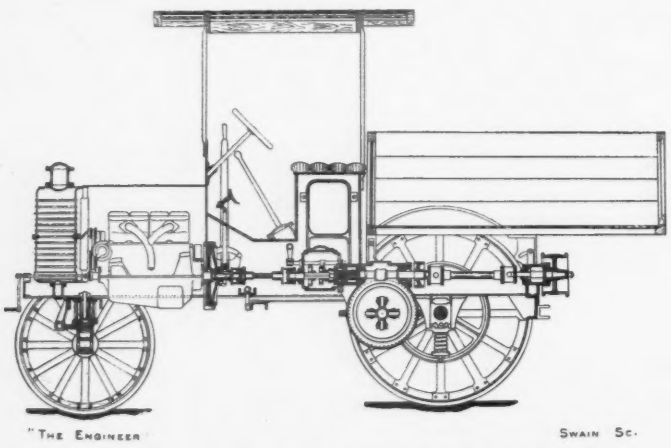


Fig. 2—30 HORSE-POWER DAIMLER PETROL TRACTOR

Fig. 4—GEAR BOX OF 100 HORSE-POWER TRACTOR

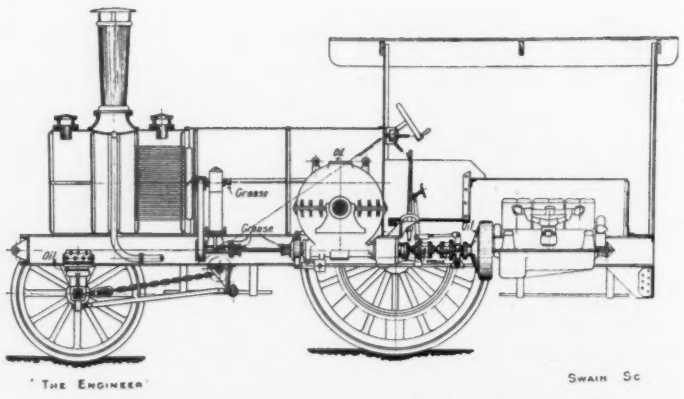


Fig. 3—100 HORSE-POWER DAIMLER PETROL TRACTOR

steam at the high pressure of 180 lb. per square inch, and in order to utilise this high pressure satisfactorily an automatic expansion gear is provided. This is of the Rider pattern, and consists of main and expansion slide valves in the steam chest, which limit the periods of admission and exhaust, and also the amount of steam admitted to the cylinder under the control of a powerful governor. Another special feature of this engine, which is, however, not visible by outside inspection, is the fire-box. This has been designed to overcome the difficulty met with in cleaning the top of the box when bad water has to be used. As will be seen from the illustration, Fig. 5, the top of this fire-box has, instead of the usual stays, corrugations pressed in the box itself. These spring from opposite corners of the box, crossing diagonally in the middle. These corrugations are obtained without undue stressing of the plate, and their strength has, we are informed, been proved by tests, not only by hydraulic pressure up to 400 lb. per square inch, but also in actual steaming at the pressure of 180 lb. per square inch.

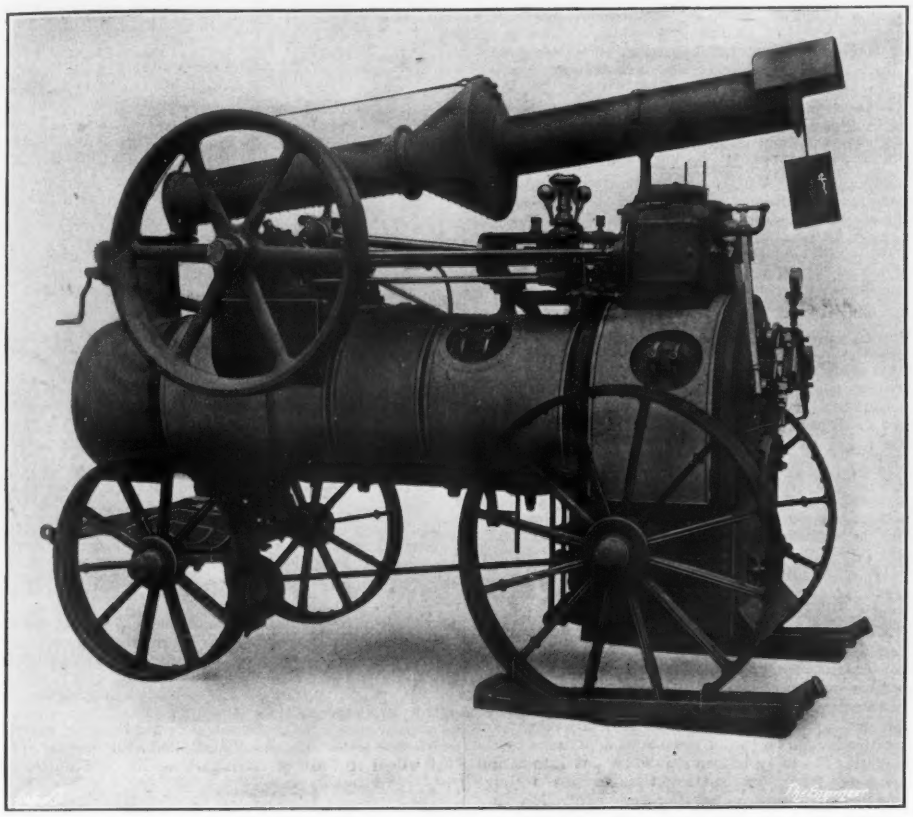


Fig. 6—MARSHALL'S PORTABLE STEAM ENGINE

The shape of the corrugations enables the plates to "breathe" freely, while a slight increase of heating surface is obtained. A further advantage claimed for this method of construction, in addition to the ease of cleaning, is that by abolishing the deep girders on top of the box the staying of the end plates is simplified by dispensing with the heavy longitudinal stays and substiting stiffeners across the plates. The crankshaft of the engine is supported in self-oiling bearings which are dust-proof. The feed pump is driven from the crank shaft by excentric and rod and delivers its water through a cast iron feed heater fitted with brass tubes, round which the exhaust steam circulates before going to the atmosphere. This addition has the effect of raising the temperature of the feed to 165 deg. Fah., and so effecting considerable economy.

To cope with the difficulties of travelling in fen countries where the roads are frequently unsuitable for mechanical haulage, Messrs. Marshall are introducing a 5 horse-power single-cylinder traction engine of light weight with driving wheels of special construction. These are of standard width fitted with diagonal soles, and extensions outside the rims. These rims travel clear of the surface on hard-faced roads, but when soft, yielding surfaces are met with the extensions come into operation and prevent the wheels from sinking. The engine is also fitted with the new fire-box just described. Two oil tractors of this firm's well-known design, road rollers, an oil engine, and a thrashing machine complete Messrs. Marshall's exhibit.

On the stand of John Fowler and Co. (Leeds), Ltd., is to be seen a new agricultural tractor weighing in working order about 6 tons, and having a 50 horse-power paraffin engine supplies the power—Figs. 7 and 12. This machine differs from most others on the market inasmuch as the engine is horizontal and is mounted on a frame resembling a locomotive boiler, the side plates of the fire-box being extended to accommodate the engine, and the barrel forming a fuel reservoir, the capacity of which is said to be sufficient for three days' working. The gearing is placed in the space corresponding to the fire-box of the steam tractor, and is thus protected from dirt. It is provided with a winding forward drum, so that the rope may be paid off at the rear through guide rollers, and when winding a load forward by means of the rope the load is pulled directly up to the coupling point of the drawbar instead of at the side. The power is transmitted through a friction clutch, and the gearing and change-speed pinions are operated by a lever from the footplate. From the differential gear motion is transmitted to internally toothed rings on the rims of the road wheels. Steering is by the usual worm and worm wheel. The engine has four cylinders, 6¼in. bore by 7in. stroke, cast in pairs, and working opposite to each other to ensure accurate balancing. The valves are arranged vertically and are operated by tappets. The cylinders and exhaust valves are water jacketed. The engine is provided with a system of forced lubrication, and there is a sensitive governor. The gearing provides three forward road speeds, 1¼, 3, and 6 miles per hour, and a reverse.

In addition to the above, Messrs. Fowler have also on exhibition double and single-ended steam ploughing appliances, road locomotives, and traction engines. For some time this firm has been making extensive experiments in steam superheating for ploughing engines, and has arranged for anyone interested to witness a set of steam ploughing engines fitted with superheaters at work not far from Norwich. The exhibitors have designed a superheater by which the steam is raised to a temperature of 608 deg. Fah. by the waste gases. The cylinders, valves, and lubricating system have, of course, all been designed to suit the new conditions of working, and arrangements are provided for cleaning the superheater by means of the steam itself. The superheater is fixed in the smoke box, and the tubes are easy of access for renewal and repairs if necessary.

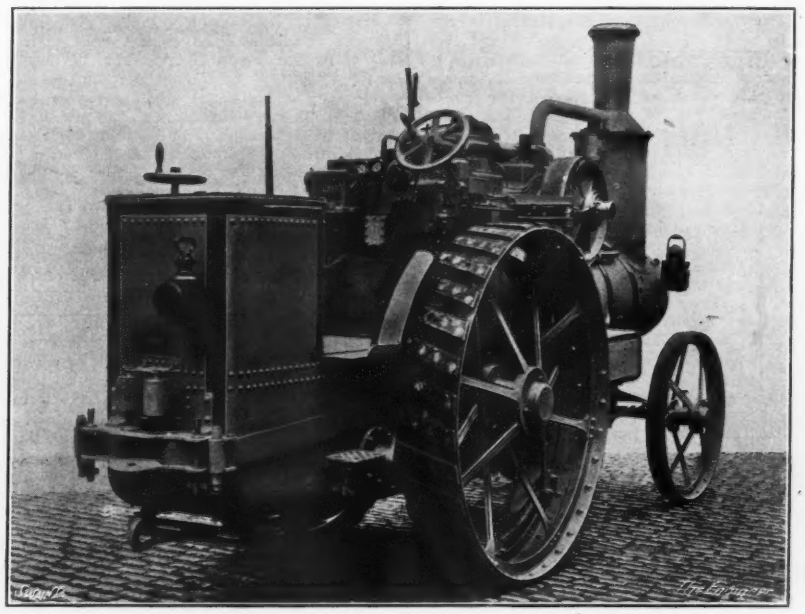


Fig. 7—FOWLER'S 50 HORSE-POWER PETROL TRACTO

Two views of a new oil tractor exhibited by Clayton and Shuttleworth, Limited, Lincoln, are given in Figs. 10 and 11. This vehicle has been specially designed for ploughing, and is calculated to be powerful enough to haul a 21-disc plough on virgin soil. The engine is of the vertical four-cylinder pattern, capable of developing from 80 to 100 horse-power at a speed of 500 revolutions per minute. It has forced lubrication to the crank shaft bearings, and a variable-speed governor controlled from the foot-plate. The fuel tank is placed over the awning, and has a capacity of 400 gallons. The ignition is by magneto, and a compression relief device is fitted to facilitate starting. The clutch is of the metal-to-metal type, and is operated by a hand wheel from the foot-plate. The change-speed gear-box is an oil-tight casing providing gearing suitable for propelling the tractor at 2¼ and 3¾ miles in a forward direction, and also contains a reversing gear. The final drive is by means of cast steel pinions meshing with internally toothed rings on the road wheels. The steering gear is of the traction engine type, and the road wheels are of ample width and diameter for travelling over soft land. The radiator is of the honeycomb variety. From the general view it will be seen that the whole of the working parts are enclosed.

One of the most interesting engines of the internal combustion type in the Show is on the stand of Willans and Robinson, Limited, Rugby. This engine combines the principle of the well-known Diesel engine with that of the high-speed steam engine. The engine exhibited works on the two-stroke cycle, and has three vertical cylinders 165 mm. diameter by 280 mm. stroke, and these are capable of developing collectively 75 brake horse-power when running at 450 revolutions per minute. Each cylinder has a trunk piston working within a moving liner, in which ports are cut to form the exhaust outlet and scavenging inlet openings. This liner is operated by two excentrics formed on crank webs, and has half the stroke of the working piston. The air for scavenging is compressed by means of an annular piston formed on the bottom end of the liner, and is stored in a chamber in the engine casing common to all cylinders. The cylinder head over which the liner moves takes the form of a fixed piston with a concave lower surface corresponding with the top of the piston, and through the fixed piston oil is sprayed by compressed air at a graduated rate on the top dead centre, on the Diesel principle. All the main bearings have forced lubrication. The starting gear and fuel valve fitted on each cylinder are operated so that they cannot be used simultaneously. The fuel pumps are driven by excentrics from the cam shaft, and the governor operates by holding open the suction valves for a longer or shorter portion of the pumping stroke.

Another interesting engine, which embodies some of the Diesel engine characteristics, is shown by Petters Limited, of Yeovil. It also works on the two-stroke cycle. The vaporiser is heated in the first instance by means of a lamp, which may be afterwards extinguished. At the end of the firing stroke the exhaust ports are uncovered by the piston, and the exhaust gases are expelled by the inrush of air previously compressed in the crank chamber. The oil fuel is pumped into the vaporiser under pressure at the end of the compression stroke, and is intimately mixed with the compressed air so as to ensure perfect combustion. The speed of the engine is controlled by an inertia governor operating on the fuel pump. The cooling water is circulated through the cylinder jacket by means of a pump driven from the crank shaft. Lubrication of the main bearings is effected by rings dipping in oil wells, and the piston and cylinder and large end of the connecting-rod are oiled positively by means of a pump driven off the crank shaft. The engine is provided with a self-starter, which consists of a compressed air receiver, fitted with connecting pipes, starting valve, stop-cock, and a pressure gauge. This receiver is charged when the engine is working. Messrs. Petter, among other exhibits, also show an 18-20 horse-power oil tractor in which the propelling agent is a two-stroke vertical engine, and a 30 horse-power oil

traction engine with two speeds forward and one reverse speed.

J. W. Brooke and Co., Limited, Lowestoft, show a vertical 10 horse-power paraffin engine of new design, which is started up by a blow-lamp and afterwards requires no ignition apparatus. The charge of oil is sprayed into the cylinder by means of a pump. The engine has a governor, which is arranged to act in conjunction with a by-pass for the fuel. A noteworthy feature of this engine is its accessibility, and in this respect it may be noted that the whole of the pump unit can be removed by slacking three nuts. This firm also shows 3 horse-power and 4 horse-power paraffin engines suitable for farm and dairy work. Besides showing agricultural implements, Messrs. Blackstone exhibit a varied assortment of oil engines of the self-igniting pattern. The crude oil engine shown by this firm works on the spraying principle, that is, the fuel is injected into the cylinder at the end of each compression stroke by means of compressed air. This charge is ignited by means of a flame issuing from the orifice of an ignition chamber, the flame being caused by the combustion of a secondary spray of fuel injected therein. Oil is supplied to this secondary spray at each cycle, thus keeping the temperature of the ignition chamber sufficiently high to light the charge. The oil to the main spray is controlled by a governor. The two-cylinder vertical marine engine shown by Messrs. Blackstone is also designed to operate with crude oil. The engine is self-starting, and is fitted with a clutch-actuated reversing gear, working on the epicyclic principle. These engines are made with one, two, three and four cylinders, from 10 to 180 brake horse-power. The number of exhibitors of internal combustion engines is, perhaps, larger than usual at these Shows, the list including Richard Hornsby and Sons, Limited; the Eagle Engineering Company, Warwick; Collingham and Owen, Beeston, Notts; Russell, Newbery and Co., Altrincham; W. J. Bates and Co., Manchester; National Gas Engine Company, Limited, Ashton-under-Lyne; Tangyes Limited; Campbell Gas Engine Company; Capel and Co., London; Boulton and Paul, Limited, Norwich; the Bristol Wagon and Carriage Works Company; Alfred Dodman and Co., Limited, King's Lynn; Davey, Paxman and Co., Colchester; E. R. and F. Turner, Limited, Ipswich; R. A. Lister and Co., Limited, Dursley; W. H. Key, Norwich; and Ruston, Proctor and Co., Limited, Lincoln. The engine shown by the last-named firm is of 16 brake horse power, and has two fly-wheels and a centrifugal governor. A feature of this engine, which applies to all sizes, is the automatic oil ring bearings for the crank shaft. In some of the larger sizes of oil engines made by this firm forced lubrication is applied to the cylinder, and continuous lubrication to the crank pin, while the lay shaft has ring-oiled bearings. The other features of these engines include special facility for cleaning out the water jackets, a desirable feature in districts where impure water only is available. The methods of ignition and vaporising are well known.

Several sizes of gas engines are shown by Davey, Paxman and Co., Limited, Colchester. The design of these engines is quite up to date, throttle governing, supported cylinders, four-part main bearings, chain lubrication to the side shaft and crank shaft bearings, water-cooled exhaust valves, renewable valve seats, and independent air silencer and air regulator form some of the features. A 30 brake horse-power gas engine has both air and exhaust valves operated by single cams, and the breech end is designed to allow of expansion and contraction under varied conditions of working. Although this engine operates on the hit-and-miss principle of governing, a cam is provided whereby up to a certain point governing is effected by varying the quality of the mixture. This engine is fitted with variable magneto ignition.

The Campbell Gas Engine Company, Halifax, is represented by a 30 brake horse-power gas engine and open-hearth suction plant, and a group of oil engines. In the latest model of oil engine the exhaust valve is the only valve mechanically operated. The oil is drawn into the vaporiser automatically without the aid of oil pumps, and there are no moving parts in the vaporiser or igniter. The engine is fitted with a centrifugal governor, which varies the number of charges of gas admitted to the cylinder in accordance with the load. The governor is driven by machine-cut gears from the lay shaft. The inlet and exhaust valves have removable boxes, with ground joints for easy removal and replacement. The Campbell oil engine is certainly as simple in design as is practically possible. Other makers of gas and oil engines of their respective standard types are the National Gas Engine Company, Limited, Ashton-under Lyne, and Tangyes Limited, Birmingham.

There is the usual good display of steam road locomotives, traction engines, and light steam tractors, and it speaks well for English makers that they find no necessity to make alterations of any note. The exhibitors include Charles Burrell and Sons, Limited, Thetford; Alfred Dodman, King's Lynn; Davey, Paxman and Co.; Wallis and Steevens, Basingstoke; William Allchin, Northampton; Thomas Green and Son, Leeds; J. and H. McLaren, Leeds; Ruston, Proctor and Co., Robey and Co., Limited, William Foster and Co., Limited, W. Tasker and Sons, Limited, and Fodens Limited. Messrs. McLaren's exhibits included a steam tractor similar to that with which they won the Society's gold medal in the ploughing competitions last year. This engine has three speeds for ploughing, a feed-water heater, and a superheater. The engine is compound, and the boiler is designed for a pressure of 200 lb. per square inch. In the competition referred to, a sister engine travelling at an average speed of 3½ miles per hour ploughed 5 acres at the rate of 1 acre per hour with a coal consumption of less than 55 lb. of coal per acre. Messrs. McLaren also show a series of ploughs specially designed for steam tractors. One designed to take six furrows is made self-lifting, with steerage and means for regulating the depth of cut. Aveling and Porter, Limited, Rochester, have on view a spring-mounted road-hauling engine, a compound steam roller, a compound steam tractor, steam motor lorry, and a compound steam ploughing engine. In their road-hauling engine the whole of the shafting is carried in one plate, and by means of a special arrangement of the gears the width of the engine is kept down to a minimum. The driving wheels are 6ft. 6in. diameter. This engine is geared to provide three road speeds, which should make it particularly suitable for hilly districts. Richard Garrett and Sons, Limited, Leiston, Suffolk, besides showing traction engines, a steam motor tractor, motor wagon, a single-cylinder portable engine, have on exhibition a 65-68 brake horse-power compound condensing semi-portable engine with a superheater, which has already been described in THE ENGINEER.

The Society has awarded five silver medals amongst the implement exhibitors at Norwich—a number which is larger than usual. The winners of these awards are as follows:—Bamford and Sons, Uttoxeter, for their detachable meal sifter; one to R. A. Lister and Co., Dursley, for their automatic electric lighting plant; one to Mr. F. M. Dossor, Doncaster, for a mangold seed dresser; one to Mr. A. J. Muntz, Hungerford, for a wire strainer for fences; and one to the Aktiebolaget G. Welander and Kellners Verkstäder, Norrköping, Sweden, for a milking machine. The milking machine is an ingenious device which imitates very closely the action of the fingers. It is attached to the animal by bands, and is operated from any source of power by means of a flexible shaft which gives a reciprocating motion to rubber-faced flexible plungers working in receptacles secured to the teats. It has an advantage over some attempts that have been made, inasmuch as the flow of milk can be observed and the apparatus put out of action when the flow ceases, thus preventing injury to the animal. The power required to operate the machine is almost negligible. The automatic electric lighting installation shown by Messrs. Lister is very ingenious, and comprises (1) a petrol engine of the firm's usual design with the addition of a valve for relieving the compression when starting; (2) a shunt-wound dynamo coupled to the engine by a belt; (3) a controller similar in design to a solenoid starting switch; and (4) a switchboard of enamelled slate which contains an ammeter for indicating the current being used, a second ammeter to show the current generated, a voltmeter, a special relay which controls the starting and stopping of the plant, a safety circuit-breaker for protecting the battery and dynamo, a safety fuse, and a voltmeter switch. To start the plant it is only necessary to switch on several lamps, which are lighted direct from a battery. When, however, more lamps are switched on the extra current demanded by the lamps causes the relay instrument to be put into action. The current from the battery then passes through the automatic starting switch or controller, and is delivered to the dynamo, which then acts for the time being as an electric motor, and rotates in the same direction as the engine, to which it is connected by belt. The engine then revolves as if it were started by hand. It then commences firing, and overcoming the motor effect of the dynamo, starts generating electricity itself, delivering the current direct to the lamps, and at the same time replacing the energy which has been taken from the battery in order to start the dynamo. Assuming the number of lamps in use is below that required to start the plant and such lamps are required for a prolonged period, the voltage of the battery will drop, but this is provided for in the system, and such drop of voltage will also actuate the relay and cause the plant to start up and re-charge the battery. When the lamps are switched off, and the battery has been charged up to the standard voltage, the plant automatically stops.

The stand of Robey and Co., Limited, Lincoln, contains a variety of engineering exhibits, including a single-cylinder horizontal fixed engine, with their automatic drop valve gear, which enables it to be used for superheated steam; a compound portable engine with jet condenser; a horizontal medium stroke fixed engine, which is entirely self-contained, and practically independent of foundations; and an open type high-speed vertical engine, with shaft throttle governor, actuated direct without belt or gear. The newest feature on their stand is, however, a horizontal air compressor, fitted with their special disc valves. The compressor is belt-driven. The cylinder is 10in. bore by 10in. stroke, and when operating at 200 revolutions per minute is capable of dealing with 179 cubic feet of free air per minute. The type of valve used has already been described in THE ENGINEER.

This year the Royal Agricultural Society of England is holding two classes of competitions, one for potato diggers and the other for potato sorters, for each of which two prizes are offered. The trials will take place at Littleworth, near Spalding, in the week commencing September 24th next. Entries for diggers have been made by Blackstone and Co., Stamford; Alex. Jack and Sons, Limited, Maybole; Kuxmann and Co., 23, Bucklersbury, London, E.C.; Martin's Cultivator Company, Limited, Stamford; Powell Brothers and Whitaker, Wrexham; Ransomes, Sims and Jefferies, Limited, Ipswich; and David Wilson, Prestonkirk; and for potato sorters by Cooch and Son, Northampton; J. B. Edlington and Co., Limited, Gainsborough; George H. Lawson, Wisbech; Walter Ness, King's Kettle, Fife; and David Wilson, Prestonkirk.

We shall deal with further exhibits in the implement section next week.

CAST STEEL Y-SPOKED WHEELS FOR TRACTORS.

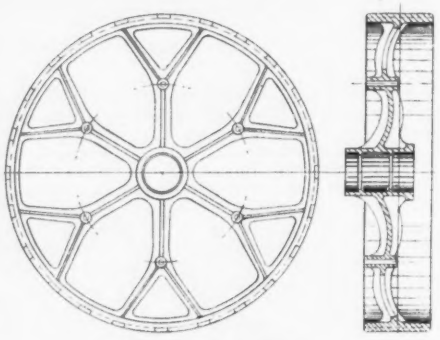
THE accompanying engraving and sectional drawing represent a special cast steel wheel that has been recently introduced and registered by the Atlas Resilient Road Wheels, Limited, Manchester. It has been specially designed for use on motor tractors and other vehicles.

The important feature of the design is the arrangement of the spokes, which are divided Y-shape at the outer end to transmit the drive to the rim of the wheel. In this way the ends of the spokes form struts, and are therefore claimed to be better able to withstand the driving stresses and road shocks. It is also claimed that the design permits of the weight of the wheels being materially reduced without taking

CAST STEEL Y-SPOKED WHEEL

away from their strength. It is pointed out that by dividing the spokes at the outer double the number of supports to the rim are provided, so that the latter can be greatly reduced in thickness, and, of course, in weight.

The spokes may be of any suitable cross section, but usually are made with a cross section in the form of a cross, so as to provide webs in the direction of rotation of the wheel and other webs substantially parallel with the axis of it. The weight of a pair of driving wheels 4ft. in diameter with



DETAILS OF WHEEL

tires 10in. wide is 8 cwt., and the front wheels 2ft. 6in. diameter by 5in. wide tires are 1½ cwt. each wheel, the set being suitable for carrying a gross load of 3 tons.

BOOKS RECEIVED.

Whittaker's Electrical Engineer's Pocket book. By Kenelm Edgcumbe. Third edition. London: Whittaker and Co., 2, White Hart-street, Paternoster-square. Price 5s. net.

The Propagation of Electric Currents in Telephone and Telegraph Conductors. By J. A. Fleming, F.R.S. London: A. Constable and Co., Limited. Price 8s. 6d. net.

The Directory of Contractors and Public Works Annual, 1911. Edited by M. Sharpe. London: The *Contractors' Chronicle*, Limited, 48, Gray's Inn-road, W.C. Price 15s.

Praktischer Schiffbau "Bootsbau." By A. Brix. Herausgegeben vom Akademischen Verein Hütte E. V. Berlin. Berlin W. 66: W. Ernst and Sohn, Wilhelmstrasse 90. Preis, geheftet M. 9, gebunden M. 10.

Versuche mit Betonsäulen. Von Professor M. Rudeloff Grosslichterfelde Vortrag gehalten auf der XIV. Hauptversammlung Des Deutschen Beton-Vereins (E.V.), am 14. Februar, 1911. Berlin: Wm. Ernst and Sohn. Preis geheftet M. 0.60.

Deutscher Ausschuss für Eisenbeton: Versuche über das Verhalten von Kupfer, Zink und Blei gegenüber Zement, Beton und den damit in Berührung stehenden Flüssigkeiten. Ausgeführt im Königlichen Materialprüfungs-Amt zu Gross-Lichterfelde-West Bericht erstattet. Von Professor E. Heyn, Direktor im Königlichen Materialprüfungsamt. Berlin: W. Ernst and Sohn. Price M 3.20.

HORSESHOE DAM ON THE BOW RIVER, ALBERTA.—Referring to the article on the building of the Horseshoe Dam on the Bow River, Alberta, which appeared in our issue of the 23rd inst., we have since its publication heard that the order for the sluices, which are all to be of the Stoney type, has been given to Ransomes and Rapier, Limited. There are to be twenty-four sluices, 27 by 11, for the dam, and five sluices, 20 by 14, for the head of land.

RAILWAY MATTERS.

THE first section of the National Tramway Company's undertaking in La Plata to be electrified, has been opened to public service.

THE general manager of the Anglo-Argentine Tramways Company states that work on the construction of the Buenos Aires tube from the Once to Plaza Mayo will commence on September 15th. All the necessary material has been ordered.

THE Long Island Railroad, we hear, has placed a single-truck storage battery car in regular operation on its Bushwick branch to replace the steam trains. The car runs between Bushwick and Bushwick Junction, a distance of 3½ miles, and makes seven round trips a day.

THE Board of Trade has recently confirmed the undermentioned Order made by the Light Railway Commissioners:—East Kent Light Railways Order, 1911, authorising the construction of light railways in the County of Kent, from Shepherdswell to Sandwich Haven, with branches from Eythorne to Coldred and to Tilmanstone, and from Eastry to Wingham.

ON the 1st of July the London Electric Railway will introduce season tickets on the Baker-street and Waterloo, the Great Northern and Piccadilly, and Hampstead lines. Tickets will be sold to cover all journeys where the ordinary fare is 2d. or over, and will be issued at half rates to children under 15 years of age, to students, apprentices, and junior clerks up to the age of 18 years.

THE Canadian Northern Railway is understood to be planning an initial expenditure of over £1,000,000, and an ultimate expenditure of about £7,000,000, for the construction of terminals in Montreal and Toronto. It is understood that there will be new terminals in Toronto and Montreal, and in connection with the latter it is proposed ultimately to throw a bridge over the St. Lawrence.

IN Canada and the United States there are altogether 46,077 miles of railway using the telephone system for train despatching, &c., of which the Canadian Pacific Railway is the largest user, with 3955 miles of the system in use. The telephone, however, costs seven or eight times more to install than the telegraph. The extra expense is considered a good investment, it is stated, in view of the greater efficiency of the new service.

SINCE the Corporation of Schöneberg-Berlin took over the duty of keeping the streets clean, steady progress, says the *Commercial Motor*, has been made in the direction of mechanical propulsion. Within the next few weeks the borough will possess a dozen electrically driven street washers, and the year 1912 is to see all horse-drawn dust carts, street sweepers and water carts replaced by the mechanical type. A special depôt is being constructed for the housing of these automobiles.

A RUSSIAN Inter-departmental Commission has passed a favourable report on the project submitted to the Government by Mr. C. H. Stewart, an English engineer, for the construction of hydro-electrical stations in the Caucasus. The report will shortly be presented for the approval of the Council of Ministers. Mr. Stewart proposes to establish two generating plants—the first on the banks of the river Terck, near the Darial Gorge, in the Tiflis Government, and the second near the mountain lake of Goktcha, in the Erivan Government. Electric power will be supplied for railways, tramways, factories, mining concerns, lighting, &c.

THE London and North-Western Railway Company has designed a special "Coronation" engine for the occasion of the Investiture of the Prince of Wales at Carnarvon in July. It weighs 58 tons 17 cwt., and the tender 39 tons 5 cwt., with 7 tons of coal and about 3000 gallons of water. On the occasion of the special Investiture trip the new engine will be painted in fancy colours, the boiler will have striking brass bands round it, and the locomotive will be generally decorated. It has been designed by Mr. Bowen Cooke, chief mechanical engineer of the London and North-Western Railway Company, and belongs to the George the Fifth class.

ACCORDING to *Engineering News*, one of the schemes for electrifying all railways entering Boston, a subject which has been much discussed recently, is likely to be favoured by the Massachusetts Legislature. The Committee on Railroads and Metropolitan Affairs on May 25th approved of a measure which provides that all the standard gauge railways within the metropolitan district shall be electrified in such a manner and in such order as the Board of Railroad Commissioners may determine. The railways are to file plans and specifications for electrification with the Railroad Commission before September 1st, 1912 The Commission will determine the extent to which public necessity demands electrification, and will also fix a date for beginning the work.

THE opening has just taken place of the Berne power station in the Berne Highland, the water power of the Kander being utilised for the operation of turbo-generators of from 9000 to 12,000 horse-power. It is intended to use the power in the form of high-pressure single-phase alternating current for the working of the Lötschberg Railway, and perhaps also for other lines. It is assumed that the Federal Railway authorities will soon approach the question of the conversion of the St. Gothard Railway to electric traction, as otherwise almost the whole stream of tourist traffic would presumably be diverted to the new Lötschberg-Simplon Railway, in consequence of the inconveniences arising, it is said, from the presence of soot on the former railway, especially as the latter line represents a considerable reduction in the distance to Italy and the Riviera from the north and north-west of Europe.

AN enormous traffic is handled by the Metropolitan Railway of Paris, as is well shown in the report for the past year. The number of passengers carried was 251,701,253, as against 254,445,992 in 1909, and 229,700,519 in 1908, while the net receipts came to 11,050,094f. last year, as compared with 11,278,778f. in 1909, and 10,306,534f. in 1908. As in the case of the other French companies, the past year proved one of considerable trial, and the company's financial position has been seriously affected by the floods, which caused a loss of some 5,000,000f. While gross receipts fell 102,000f., there was an advance of 282,000f. in expenses, and the percentage rose from 42.11 to 42.83 per cent. Rightly recognising the abnormal conditions of the past year the directors, however, propose to maintain the dividend at 20f. per share, and hold out good hopes for better results during the current twelve months.

A GASOLINE motor car has recently been supplied to the Alaska-Northern Railroad of Seward-Alaska. The car, which seats 35 persons, has the following dimensions:—Extreme length, 34ft. 2in.; width, 8ft. 6in. The engine-room, which also takes baggage, is 11ft. 1in. long. The passenger compartment is 15ft. 2in. long. The body is mounted on a single truck of 10ft. wheel base. The wheels are cast iron, 30in. in diameter. The engine is water cooled, with four cylinders, 6¾in. by 7in., and the transmission is by means of gears. There are three speeds in each direction, and the average running speed is 35 miles per hour. Two chains are attached to the front axle for the drive, and the transmission acts in conjunction with a master clutch of the disc type in the engine fly-wheel. The gears and the master clutch are so interlocked that it is impossible for two speeds to be engaged at the same time. The car is equipped with air brakes, and also a hot-water heater fed from the engine compartment. The total weight of this car is over 11 tons.

NOTES AND MEMORANDA.

A MONUMENT was unveiled in Paris on June 16th, on the Place Saint Ferdinand des Ternes, to Léon Serpollet, whose first journey from Paris to Lyons on his steam car in 1890 caused a sensation. When he first drove about the streets of Paris, numerous complaints were made to the Prefect of Police that the lives of citizens were being endangered.

THE energy from Niagara Falls, including operation on both sides of the river, states the *Electrical World*, is being used at the rate of 126,000 horse-power for electrochemical process, 56,200 horse-power for railway service, 36,400 horse-power for lighting, and 54,540 horse-power for various industrial services, the total being 273,140 horse-power. Since the water of Niagara Falls represents probably 5,000,000 horse-power, it would seem that only about 5.5 per cent. of the available power is being utilised at present.

IT has been stated that the durability of the old cements—for instance, those of the Romans—is due to a low proportion of soluble silicates and a low lime content—under 50 per cent.—and that most modern high-lime cements are deficient in resisting power when exposed to waters containing dissolved alkalis and sulphates. In America a company has begun the manufacture of a cement which it is claimed will resist alkalis and sulphates by virtue of a low lime content and an excess of silica, using limestone, shale, and blast-furnace slag as raw materials.

FOR more than two years a factory has been running at Marathon, Texas, extracting rubber from the wild guayule shrub. This shrub until a few years ago was one of the most despised of all the desert plants. It attains its best growth, so it is said, on land that is practically worthless for any other purpose. The statement is made that there are more than 6,000,000 acres in that part of Texas, on which the shrub may be grown on a commercial scale. It is propagated both by seeds and by cuttings. Other factories are projected as a result of the success of the pioneer establishment.

AN Australian invention to overcome corrosion and pitting in metals, especially boilers, due to electro-chemical action of the impurities in water with which they are brought in contact, appears to have met with success in Sydney. It introduces, by means of dynamos, weak electrical currents through the metals intended to be protected, thus neutralising the galvanic action of the corrosive substances contained in the water. The process was recently tested by the professor of physics at Melbourne University on metals immersed singly and in connected pairs in sea water, both hot and cold, and in dilute acids. He reported that all hurtful galvanic action was suspended by a small expenditure of electrical energy.

THE ultimate supply which will be derived from the works now under construction in the Derwent Valley is estimated at 33 3 million gallons daily. It will be divided in the following proportions:—Leicester, 9.8; Derby, 6.8; Sheffield, 6 8; Nottingham, 3.9; Derby County, 5; and Nottingham County, 1; these figures representing millions of gallons daily. The scheme provides for the construction of five impounding reservoirs with the aggregate area of 901 acres, and a collective capacity of 10,067 million gallons, about fifteen acres of filter beds at Bamford, a large service reservoir at Ambergate, and some 100 miles of aqueduct for distributing water to the various authorities concerned. At present, however, only the Howden and Derwent reservoirs are under construction, both of these being on the river Derwent, their capacity being 1940 and 2000 million gallons respectively. The reservoir dams are being built in millstone grit brought by rail from Grindleford, and the maximum thickness of masonry is 176ft. in each instance.

THE Tests Standing Committee of the Concrete Institute has issued an interim report dealing with the testing of the materials employed in reinforced concrete. The materials are classified under five headings, one of which is steel, for which the committee makes the following recommendations:—The steel shall attain an ultimate tensile strength of not less than 60,000 lb. per square inch and withstand a stress of at least 34,000 lb. per square inch before showing any appreciable permanent set. The contraction of area at fracture must be not less than 45 per cent. The elongation in the case of bars of 1in. diameter and under must be not less than 25 per cent., measured on a length equal to eight times the diameter of the bar tested. It is recommended that the elongation be measured in the case of bars over 1in. diameter on a length equal to four diameters of the bar, and that it should be not less than 30 per cent. All steel must stand bending cold to an angle of 180 degrees around a diameter equal to that of the piece tested, without fracturing the skin of the bent portion. Finally, the committee proposes that the steel must be free from scabs and flaws.

THERE is a difference of opinion as to the relative merits of pure lard oil and other cutting lubricants on the market. While some of the lubricants, according to *Machinery*, are useful for certain classes of work, they do not give as good results with cutting steel as can be obtained by a good grade of lard oil. After being used for a considerable time, lard oil seems to lose some of its good qualities as a cooling compound. There are several reasons for this. Some manufacturers use the same oil over and over again on different materials, such as brass, steel, &c. This is objectionable, for when lard oil has been used on brass it is practically impossible to get the fine dust separated from it in any centrifugal separator. When this oil is used on steel, especially where high-speed steels are employed, it does not give satisfactory results, owing to the fact that when the cutting tool becomes dull it generates sufficient heat to melt these small brass chips, which attach themselves to the cutting tool, and thus produce rough work. The best results are obtained from lard oil by keeping it thin, and by using it on the same materials—that is, not transferring the oil from a machine in which brass is being cut to one where it would be employed on steel. If the oil is always used on the same class of material it will be found that it does not lose any of its good qualities.

A CHEAP and effective means of softening hard water has recently come into use in Germany on a large scale. The peculiar property of zeolites—which are generally composed of varying quantities of silica, alumina, lime, soda, potash, and water—whereby they can exchange their bases for others, enables them to be utilised as softening agents, and when hard water filters slowly through layers of them the lime in the water changes place with the soda in the zeolites. In Germany there is now being produced an artificial zeolite of a uniform composition, the action of which on water is more certain. Permutit, as this substance is called, is prepared by fusing together felspar, kaolin, clay, and soda in fixed proportions, lixiviating the product in hot water, and collecting the residue. In use as a softener a period must arrive when all the soda in it has been given up and when, of course, its action ceases. It can then be easily regenerated with common salt simply by washing it thoroughly with soft water, and allowing a salt solution of 10 per cent. strength to flow through it for four or five hours; the layer of brine is then kept standing on the surface for another four or five hours. In the regeneration process the soda of the sodium chloride replaces the lime in the permutit and becomes converted into calcium chloride, which passes away in solution in the regeneration water. Permutit, it is said, is capable of reducing hardness from 53 deg. to 3.7 deg. It suffers no apparent loss in working and can be kept in use for very long periods with regeneration every four days or so. In appearance, when in a moist condition, it is of a granular, flaky form with a lustre resembling mother-of-pearl. It is of very porous texture, and when dry can absorb 50 per cent. of water.

MISCELLANEA.

IT is announced that the Russian Admiralty has completed its specifications of Dreadnoughts required for the Black Sea, and has invited the principal Russian and foreign shipbuilding firms to send in designs and tenders. Three submarines for the Black Sea have been ordered at the State Baltic yards, and three more at the Nevsky works.

THE plans for the erection of an institute at Cradley Heath to commemorate the victory won by the women chain-makers in their agitation for a living wage have been passed, and building operations will, we hear, shortly be commenced. It is intended that the institute, which will include an assembly room to accommodate 600 persons, shall be a centre of social activity in the Black Country.

IT appears from a report in the *Nieuwe Rotterdamsche Courant* of 14th June that the "Hollandsche Aannemingmaatschappij," domiciled at The Hague, has been awarded the contract for the carrying out of the proposed extensive harbour works at Sourabaya. The cost of the undertaking is estimated at £1,067,000, but it is stated that the figure will reach £1,167,000, when the cost of various supplementary works is included.

A CENTRAL electricity generating station of 6000 horse-power capacity is about to be established by the Landkraft Gesellschaft, of Leipzig, in connection with the collieries of the Leipziger Braunkohlenwerke Ges. at Kulkurtz, Saxony. The current will be generated at 2000 volts and transmitted at 30,000 volts. It is expected that the new station will be able to supply current for lighting and power purposes to no less than 19 towns and 604 villages in the district.

THE Chester Town Council has recently been considering a scheme for utilising the water power of the river Dee at the Dee Mills. The Lighting Committee has recommended that it be authorised to obtain the opinion of an expert on the scheme, and, in the event of such expert opinion being favourable to the adoption of the scheme, the Committee be authorised to proceed with it. The Committee also desires sanction to apply to the Local Government Board to borrow £5000 towards executing the works, which it is estimated will cost £10,000.

IT is reported that all the capital—£2,000,000—required for the establishment of the British-Canadian Shipbuilding and Dock Company has now been subscribed. The company will establish shipbuilding yards, docks, and shops at Sydney, Nova Scotia, where some 300 acres of land have been purchased. It is proposed to bid for the construction of Canada's four armoured cruisers and six destroyers. It is also stated that the company intends to establish a line of fast ships between Canada and England, making Sydney and Fishguard the terminals. Three 26-knot vessels of an improved Mauretania class will be constructed. The shipyard will have 11 building slips, eight of them capable of taking the largest ships, and a dry dock 110ft. × 1040ft. The plans also include the erection of an armour plate plant.

PROVISION is made, according to the *Naval and Military Record*, in the design for the submarines of "E" class, being built at Chatham and Barrow, for the boats to carry quick-firing guns, in addition to an increased number of torpedo tubes. It has been rumbured for some time past that this important development was contemplated, but until now the statement has lacked confirmation. There is, however, no longer any reason to doubt that the "E" class will be equipped with above-water armament, besides which they will be faster and have a greater radius of action than their immediate predecessors. The submerged displacement of the "E" class will be 800 tons, compared with 604 tons of the "C" class, and their surface speed will be 15 knots, which is two knots in excess of the "C" boats.

IN the House of Commons recently a question was put by Mr. A. Fell as to whether any reason could be given for the increase in the amount of steel in the form of ingots, blooms, billets, slabs, sheet bars, and tin-plate bars which had been imported into this country during the first four months of this year. Mr. Tennant replied that the imported steel was being offered to consumers in this country at lower prices than those charged by British steel makers; but it was not possible to say definitely how far this was due to temporary over-production abroad and how far to lower cost of production arising from improved equipment. As between this year and last the increase in the imports from Germany, though considerable, had not been nearly so great as the increase in the imports from the United States of America.

A RECENT issue of the *Journal* of the British Fire Prevention Committee contains a convenient summary of the results furnished by twenty-eight tests conducted at various dates on fire-resisting floors. All the tests in question have already been fully described, and the object of the summary referred to is to collect under one cover the general results in a manner suitable for reference. Apart from explanatory notes, the particulars are given in the form of two folding plates relating to floors classified as affording "full protection" and "partial protection" respectively. The tables only refer to a few of the numerous types of construction on the market, and it is to be noticed, says the *Builder*, that there are many excellent floors which have not been submitted for test by the Committee. It should also be noted that the tables are merely summaries intended as a general guide to the forms of construction to which reference is made. Further details can be obtained from the original reports, the number and date of each being given in the two tables.

A CONSULAR report on the trade of Roumania in 1910 states that the increasing uses to which petroleum and its products are being adapted have had their effect on the local industry. This may be noted from the various new companies that have recently started and the activity and development of the existing companies. The petroleum of Roumania, the report states, is of exceptional quality, and in some districts, such as that of Bacau, the oil comes to the surface in an almost pure condition. The quantity of petroleum must be enormous, as the district extends over a large area of country, and, in fact, some experts hold that oil will be found throughout the entire anticline caused by the Carpathian Mountains. Though a great industry has sprung up and large quantities of oil are annually extracted, there are experts who declare that only the surface has been tapped. The production of crude oil in the year 1890 was 53,300 tons, of the value of £85,280, whereas last year the production was 1,352,289 tons, and the value £1,893,204. The total value of the exports of oil products in 1890 was only £23,546, while the figure for 1910 was £1,603,838.

IN a recent report the American Consul at Johannesburg says that supplies for Transvaal mines and works are practically all purchased through local dealers or representatives acting for the foreign manufacturer. "Thus, American manufacturers interested in securing a share of this business must of necessity have their representatives or agents on the ground to submit bids when tenders are asked for, or in other cases personally to solicit orders. Nearly all the leading mine machinery concerns of the world, including several American firms, are thus represented, while numerous other manufacturers of mining supplies of various kinds have resident agents. Competition is keen in the mining trade, especially in the matter of electrical machinery and supplies. German manufacturers have for years been making a strong bid for this particular line, and it is common knowledge that their success in securing orders is due almost entirely to the fact that the prices submitted by them are as a rule lower than those of American or other foreign firms. Prices here, as elsewhere, are powerful factors in securing orders, and the business is almost certain to go to the concern quoting lowest."

TRACTORS AT THE ROYAL AGRICULTURAL SHOW

(For description see page 668)

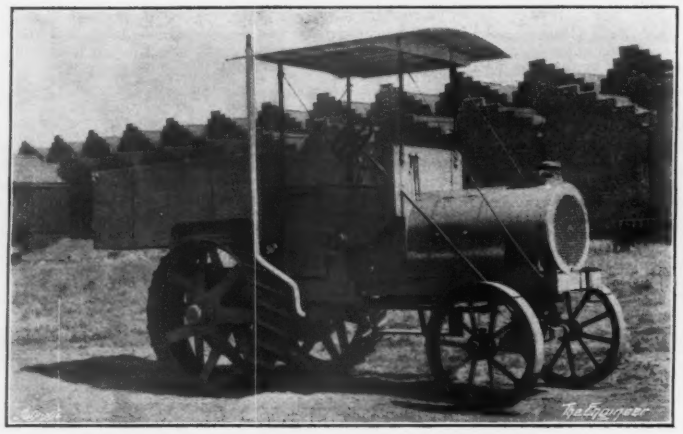


Fig. 8—80 HORSE-POWER DAIMLER PETROL TRACTOR

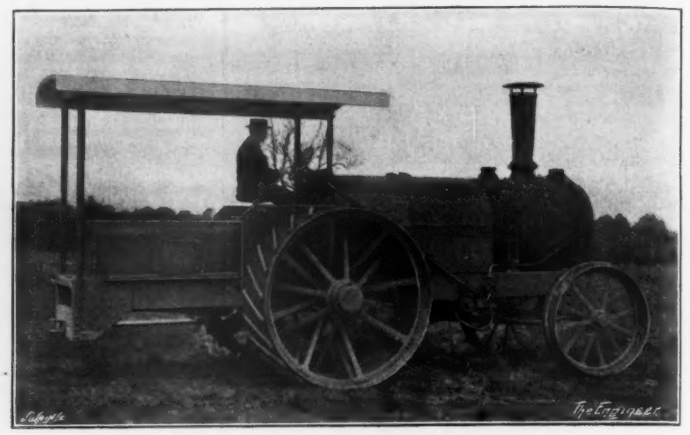


Fig. 9—100 HORSE-POWER DAIMLER PETROL TRACTOR

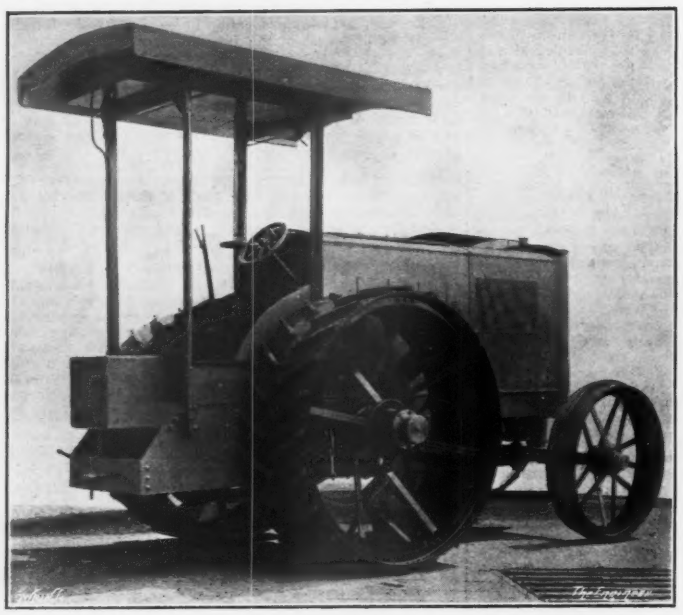


Fig. 10—CLAYTON AND SHUTTLEWORTH'S OIL TRACTOR

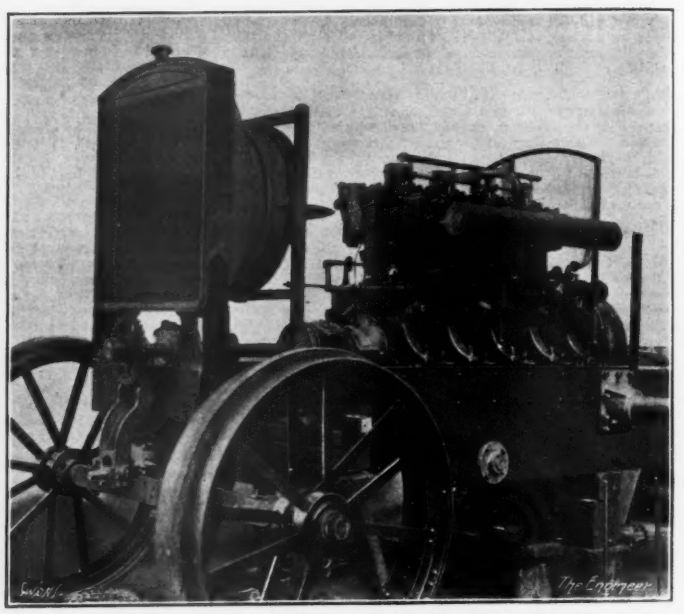


Fig. 11 CLAYTON AND SHUTTLEWORTH'S OIL TRACTOR

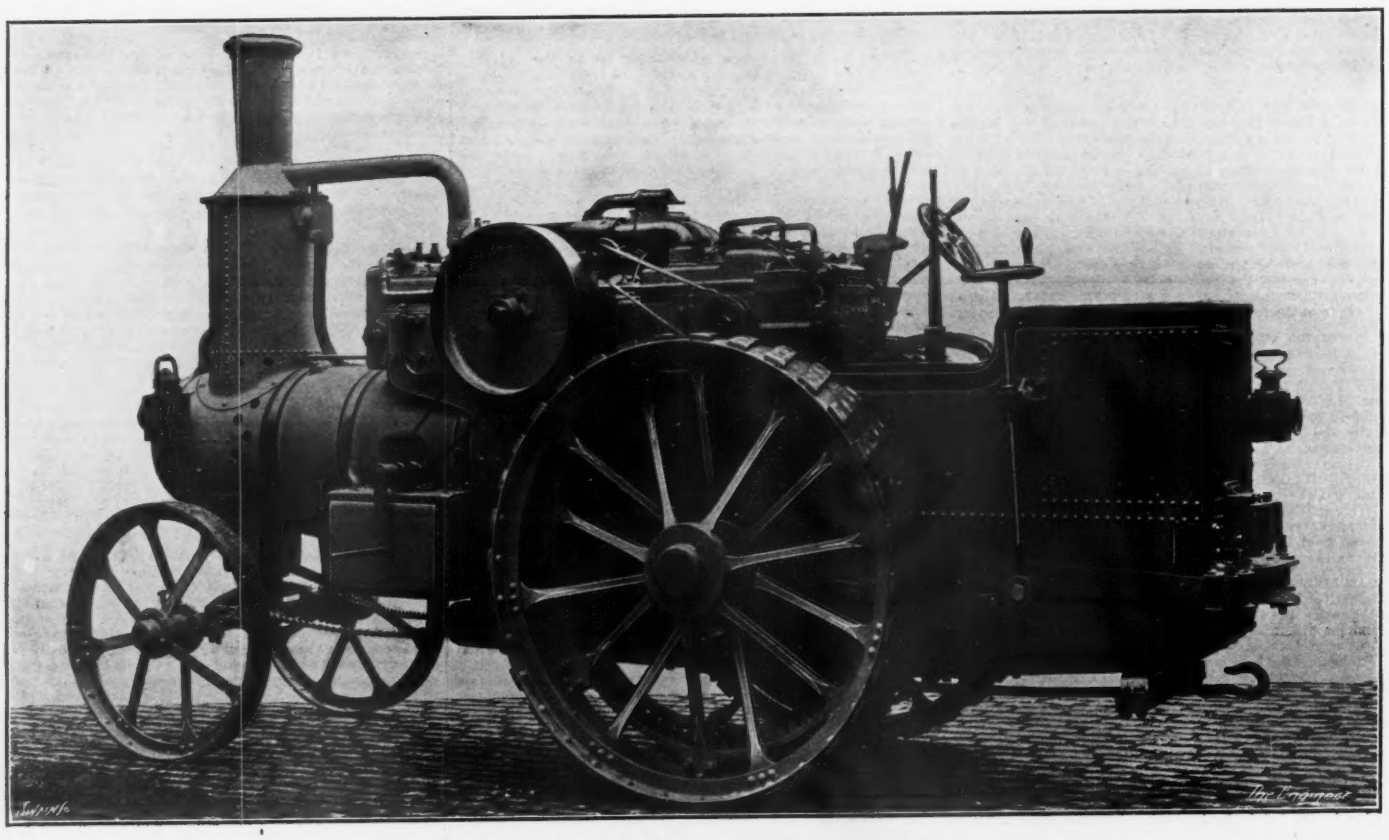


Fig. 12—FOWLER'S 50 HORSE-POWER PETROL TRACTOR

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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MEETINGS NEXT WEEK.

(*See "Forthcoming Engagements" page* 682.)

THE ENGINEER.

JUNE 30, 1911.

The Value of a Vacuum.

THE discussion on Mr. Morison's paper has overflowed into our own correspondence columns, and needs some adjustment in order that it may be really useful. The issues are quite simple individually, but they have been mixed up and confused to a deplorable extent. The primary question for consideration is the value to be attached to various amounts of vacuum. Then we have to consider in what terms the value can be best stated. The secondary question is the competence of feed-water heaters utilising the waste steam from donkey pumps, electrical engines, steam winches, and so forth, to make the feed hot enough. The third question is the amount of saving in fuel that can be effected by substituting the heat of the exhaust steam from the auxiliaries for that surrendered by cooling the condenser to get a better vacuum. There are besides various minor side issues. We have here, it is easy to see, matter enough for interminable disputes and disquisitions if facts and assumptions are sufficiently mixed. The proper course to pursue is to settle one point at a time, and then we can, perhaps, combine results in a way that is satisfactory.

Fortunately, the problem of heating the feed water seems to present no difficulties. It is generally admitted that the auxiliaries in at all events large modern steamers can raise the temperature of the feed water as high a point as the feed pumps can deal with. Whether it could or would not be better to use pumps which could work with hotter water is not asked. Of course, all depends on the position of the heater—whether, in other words, it is on the suction or on the delivery side of the pump. The contention that the auxiliaries exhaust is not sufficient may be brushed on one side. It can only apply to quite small steamers, which have, in fact, no auxiliaries. That it is better to raise the temperature of the feed above that of the normal hot well no one disputes. Not only is economy of fuel promoted, but the boiler is spared stresses and its life prolonged. If it were possible to send water in at boiling temperature, it would be advisable to do so; but this is, of course, out of the question if we use only the auxiliaries. It requires no argument to prove, however, that the temperature of the exhaust can raise that of the feed water to a very satisfactory degree. If, then, we find in a large ship that the auxiliaries exhaust is not used, and that the vacuum is kept poor by choice, it is clear that some commercial reason must exist to account for an apparently wasteful policy. Thus the first cost of the feed heating plant may be regarded as too great, or it will take up too much room. But no argument of this kind can have any but an isolated application; it cannot be generally justifiable. We may take it, then, as proved that it is not necessary to rely on the hot well for raising the temperature of the feed water. We might if we could reduce the temperature of the condenser to almost the freezing point, and still be able to pump very hot water into our boilers. It is necessary to be very definite and clear about this proposition, because a few authorities say that the auxiliary exhaust is not sufficient. This, as we have said, may be granted as regards some vessels. But it is not true of any ship lighted by electricity or provided with refrigerating rooms, and for the time we are writing only about ships of this type. Even in smaller vessels we have steam steering gear, distillers, and pumps, which represent a considerable percentage of the whole power generated.

Turning now to the primary question, namely, the amount of economy to be secured by augmenting the vacuum, we find again a tendency to confuse the issues by measuring this saving in different ways. Thus we have it stated that the average effective pressure throughout the engine is raised, and savings are expressed in terms of this argument. Or the engines run faster, or their speed being kept unaltered, they use less steam, and so on. All these things may be true, but they in no way affect the simple facts on which all percentages of saving should be based. This is, that the available or net work to be had from the low-pressure cylinder depends, other things being equal, on the back pressure which the piston has to overcome. As that is reduced the net work will increase. That is the whole proposition in a nutshell. Take the case of a triple-expansion marine engine. The work to be done in the first cylinder by the steam may be represented by A and B. The first, A, is employed in turning the crank shaft, and is measured by the indicator. The second, B, is expended in overcoming the back pressure resisting the advance of the piston. But it must be remembered that the liquefaction due to the performance of work is that proper to A + B, and not to A alone, as is very frequently assumed. Part of B is transferred to the second cylinder; but only in part, because of "drop" and for other reasons which we need not stop to consider here. The work done in the second cylinder may be represented by $A_1 + B_1$, the first, A_1, showing on the indicator card, the second, B_1, being as before expended in overcoming the back pressure, and forcing the steam into the low-pressure cylinder. Once more the work may be divided under two heads, $A_2 + B_2$, the latter being expended in overcoming the resistance due to the back pressure in the condenser. Now a little thought will show that nothing that concerns B_2 can possibly affect anything going on in the two first cylinders. The sum of $A_2 + B_2$ must remain the same, no matter what happens. In other words, the useful and non-useful work will represent the total work in any cylinder, and, consequently, the less we can make B_2 the greater will be A_2, and *vice versâ*. But nothing we can do in the way of reducing back pressure in the low-pressure cylinder can modify pressure changes in the cylinders which precede it. This being so, the saving to be effected by augmenting vacuum takes the form of an increase in the net, or indicated, horse-power developed in the low-pressure cylinder, in the way explained in our impression for the 9th inst., and the percentage, which is only a matter of figures, will vary with the dimensions of the low-pressure piston.

It is necessary to point out that, as we have stated above, an element of confusion may be very easily introduced here. The probable effect of the increase in torque, brought about in the way named, will be to make the engines run a little faster; and the percentage of gain may be expressed in terms of revolutions. Thus, if an engine makes 100 revolutions with a 26in. vacuum and 105 revolutions with a 28in., it may be said that the gain is 5 per cent., which may be a wholly misleading statement. Again, instead of augmenting the power, steam may be saved, the power remaining as before, by altering the cut-off in the high-pressure cylinder. In this way percentages may be calculated on a quite different basis with different results. The only sound way is that which we have explained. On the vacuum in the condenser depends, other things being equal, the net power to be got out of the low-pressure cylinder, and we need in no way take the other cylinders into account. They have nothing to do directly with the condenser.

It has been said in the course of the discussion on Mr. Morison's paper that it is impossible to make ports big enough to deal with the enormous volume of low-pressure steam when the vacuum is improved; and the turbine is cited as an illustration. But there is no true analogy between the two cases. The cylinder of a reciprocating engine has a fixed capacity, and no matter what the density of the steam the volume it has to discharge per stroke remains the same. It is the condenser that has to deal with increased volume, not the cylinder ports. Apparently there is no real difficulty in this. If we watch the hand of a vacuum gauge on the platform when a pair of large compound paddle engines are running at, say, 35 or 40 revolutions per minute, it will be seen that the merest flicker attends the entrance into the condenser of the exhaust at the end of each stroke. To all intents and purposes the annihilation of the steam is instantaneous and complete. We need do no more than refer our readers to Mr. Morison for a consideration of the part that air plays in keeping down the vacuum.

In considering the value of a vacuum it is useless

to compare the turbine with the piston engine. The efficiency of the turbine is improved by the reduction of the resistance due to blade friction by lowering the condenser pressure. The gain represented by the lengthening of the toe of the calculated diagram is a mere trifle as compared with that due to this reduction of frictional resistance; at all events, that is the received opinion. As it is of course impossible to learn anything directly about the total power generated in a turbine, only the net or brake power being measurable, there is some room for surmise as to the precise figures. The conditions are, however, so obviously different that it is pure waste of time to compare percentages of gain and loss in the piston and the turbine engine.

A review of the whole discussion and of the facts leads to the conclusion that Mr. Morison has proved his case, and that in all but a small percentage of ships good vacuums are worth having. In the best practice, however, the gain can be but little. If the price to be paid for the apparatus required to utilise the auxiliary exhaust and get rid of air from the condenser is small, then the capital outlay may be regarded as a good investment. The first thing to be demonstrated was that hot feed and a good vacuum may go together. Of this there is no longer any doubt. Mr. Morison's paper and the long discussion which followed it seem to have settled this point. The question which the shipowner wishes answered is the cost of the improvement. Perhaps some of our correspondents will supply information on this point.

Invention.

IN his article on the British inventor, which we print on another page, Mr. Horsnaill raises a number of interesting points. With much that he says we are in agreement, but we are not prepared to endorse all his observations, and we print his contribution principally because it raises matter for discussion.

Mr. Horsnaill starts from the assumption that British invention is in a backward state at the present time, an assumption that we cannot for a moment admit. We will invite our correspondent to take one single example embracing all forms of British inventiveness, and tell us if he can in any part of the world find its superior, or even its equal. Our example shall be a man-of-war in his Majesty's Navy. From beginning to end she is the product of British imagination, British thought, and British skill, and it will not be denied that she contains a collection of inventions for which it would be hard to find an equal outside of an international exhibition. We are not going to attempt the impossible task of separating the details of her contents according to the nationality of thought which first inspired them, though, if we did so, the preponderance of British inventiveness would be enormous, but we shall content ourselves by pointing out that nearly every one of the million details which may be found within her walls has been thought out in British drawing-offices. What that means any engineer who has the opportunity of studying a battleship may learn quickly for himself. It has involved knowledge of the highest kind with regard to materials and methods of production, and has called for inventiveness of a very high order. Let any one study alone the beautiful mechanism which is employed for the training, elevating, loading, aiming, firing, and running out of a 13.5in. gun, and if he has still doubts of the inventive ability of British engineers, he is in a bad way. Let him, moreover, remember that the "works" of a battleship of to-day always show some advance upon the "works" of the battleship of yesterday. As each succeeding class is produced new improvements are added, and every improvement means new invention. Our correspondent may say that much that is in her is inspired by foreign thought. Quite true, but equally true of every other nation. No nation stands alone in knowledge; there is a continual interchange, and it would defy a Royal Commission of the ablest abilities in the world to name the originator of the first thought which led to any new invention. The truth is that invention does not lie, as so many people apparently believe, in the thought, but in the application of it. An idea may be regarded like the Hertzian waves sent out by an induction coil. To men they are useless, valueless, till they strike upon some receptive organ, such as a coherer which is instrumental in turning them to use. Years and years ago, long before they were realised, locomotives and flying machines were adumbrated by poets and other imaginative people. But no one in their senses would call these people the true and original inventors. A truth forgotten by thousands every year is that an idea is not an invention. That is a fact recognised by all patent offices, for they refuse to give protection to principles, which are ideas pure and simple; a patent is only procurable for a certain definite arrangement of component parts, or for a definite method. It is the realisation of the idea, not the idea itself, which is given protection. The man in the street who invents frequently forgets that more often than not he has nothing more than an idea to offer to a manufacturer, and he reviles the manufacturer for his supineness when he refuses to pay him a good round sum for it. The manufacturer, on the other hand, knows by experience that the idea is a very small step on the road, and that real invention lies in the application. We have heard a hundred times people claim that they had invented certain things that had eventually come to success. All they mean is that at some time or other they had made the suggestion; they had never worked out the details, never made the experiments, never gone to the expense which the realisation of a bare suggestion involves. That is the "poor inventor's" weak spot. He has never the money and rarely the knowledge and ability to bring his idea to fruition. His services in that direction are of very little use to the world, and it may be looked upon as a misfortune that in rare instances, here and there, he succeeds in making a fortune. On this matter we are in thorough agreement with Mr. Horsnaill. The right place for the inventor is the drawing-office, and it will be found, as Mr. Siemens pointed out in his presidential address to the Institution of Civil Engineers, that those not actually engaged in an industry very rarely invent anything of real service to that industry. It is not their fault; it is the lack of opportunity. This is a view which might be developed at considerable extent, but we must reserve space to say a few words about scientific invention.

Mr. Horsnaill appears to consider that British engineers do not make as much use of science as foreign, and particularly German, engineers. Dr. Nicolson made the same charge, and we invited him to substantiate it. He did not do so. What he might have been able to do was to show that after a certain stage of development has been reached the German analyses and stereotypes conceptions in a way the Briton rarely does. Take, for example, the dished ends of boiler drums. After they had been made successfully for many years, an exhaustive German investigation into their deflection was undertaken. It was a brilliant piece of work, but it has not, as far as we are aware, caused any change in the design or construction of drum ends. In Germany, again, much has been done in the development of big gas engines. But how? By progressive mechanical development. And so equally with steam engines, boilers, turbines, and machine tools. It would, indeed, be easy to take case after case to show that no invention ever springs complete from the brain of man. It begins with an idea, an abstract conception, which must be put into material by one form or another before it is valuable. Then step by step the material must be moulded into new forms until something really serviceable is reached. When the motor car first came before the world engineers were in possession of an enormous mass of scientific and mechanical knowledge on the propulsion of vehicles. But not one of them was able to conceive such a vehicle as we know at the present day. Their knowledge was at fault in a thousand unexpected directions, and it was only by careful development in the works—not in the brain of inventors so much as in the brains of draughtsmen—that the car became a trustworthy and reliable road vehicle. Many of the improvements have been the subjects of patents, and are in a sense inventions, it is true, but not by any means in the sense that they have introduced new ideas to the world. For the most part they are no more than the intelligent application of old ideas to new purposes. In this direction we can assert, without fear of contradiction, that the British engineer is unsurpassed. The thorough practicalness of his nature, frequently the very fact that he is not scientific, makes him concentrate his attention on the details that pay, the correction of little faults pointed out to him by his customers, and the embodiment of new designs inspired by the consideration of the work his machines are called upon to perform.

Mr. Horsnaill appears to hold that British engineers are content to copy the inventions of foreigners. That is true to only a very limited extent. In our experience it never happens that a foreign invention is not improved, frequently out of recognition, by the treatment it receives in British hands. That there is a regrettable tendency at the present time for our manufacturers to adopt foreign inventions we do not deny, but it is not so much from lack of ability on their own parts as from lack of means to make costly experiments. Take, for example, the electrical industry. Everyone knows that it is extremely difficult to make even fair dividends. How, then, can the directors venture to sanction the expenditure of large sums on experimenting when the safer course of adopting foreign inventions on which the necessary experiments have been made presents itself? Invention, after all, is controlled by money. When the industries of this country were enormously successful there was no lack of invention; and when again, if ever the time comes, there is spare capital to invest in experiments, the British inventor will show himself equal to any in the world.

Limitation of the Production of Coal.

THE question of limiting the production of coal, which is now engaging the attention of colliery owners in Scotland, is by no means a new one, as it has been previously raised in Great Britain on different occasions during the past twenty years, particularly in South Wales, whilst at the same time suggestions were made several years ago in favour of difficulties being placed in the way of the export of Welsh smokeless coal, so as to conserve the supplies for the use of the Navy. But no progress has been made with any proposals put forward with the object of curtailing the output of coal, and the situation in each coal-mining district has practically remained the same year after year from this particular point of view. It is, however, only during periods of unfavourable business of a district or general character, when the production of coal exceeds the demand and sale prices are declared to be either unprofitable or scarcely remunerative, that anything is heard in this country from the coal owning interests of schemes for controlling the output, and thus endeavouring to influence prices in an upward direction. Yet it is precisely the economic law of supply and demand which operates to the advantage of consumers in general when over-production takes place, and to the benefit of the colliery owners when the quantity of coal raised does not meet the requirements for the time being. Since 1890 the total output of coal in the United Kingdom has increased by 83,000,000 tons, and the maximum was reached in 1907, when 267,812,000 tons were brought to the surface. As is known, the export trade has also made considerable progress in the same period of years, although not to a corresponding extent, and it likewise attained to high-water mark in the year 1907. Since then the quantity of coal sent abroad, exclusive of fuel shipped for the use of steamers engaged in the foreign trade, has experienced a diminution, owing to the operation of a variety of causes, down to the end of 1910, especially in consequence of the development of foreign competition, which is endeavouring, not without a certain amount of success in recent years, to wrest external markets from British coal producers and exporters.

The present year has, however, brought about a remarkable change in the situation of the British export trade in coal, inasmuch as the business has received a noteworthy impetus in a number of markets, and the first five months show an augmentation of 2,480,000 tons over the equivalent period in 1910. If this rate of progression is proportionately maintained during the remainder of the year, it will be found that the total exports will amount to approximately the same as in the record year of 1907. Yet it is under circumstances of this nature that the Scotch colliery owners complain of low prices and over-production of coal. It is, of course, quite possible for one coal mining district to gain an advantage at the expense of another, as has occurred on many former occasions, and as the Scotch coalowners have already suffered a loss of 45,000 tons in exports, so far as nearly the first half of the present year is concerned, it follows from the large increase in the Board of Trade returns that other centres of production must have received a stimulus in the shipments to other countries. The question in Scotland was recently first raised by the Lanarkshire Coalowners' Association, which has discussed various proposals for dealing with the problem of over-production and the decline in prices. One of the schemes aims at the reduction of the number of working days per week to four. The movement in favour of action in the matter has now spread to the Lothians, Fifeshire,

and Ayrshire, and communications have been opened with the similar associations in these localities with a view to the adoption of united action. It is admitted that the difficulties in the way of arriving at a general agreement are considerable, but unless they are surmounted the existing conditions may be expected to continue until the demand improves with the course of time, or some other possible remedy is brought forward for discussion.

It is of some interest to point out in this connection, although not as an example worthy of emulation in any part of Great Britain, that an attempt has been made to solve the problem of over-production and low prices in the west of Germany. The scheme, which has been in successful operation for a number of years past, relates to the well-known undertaking of the Rhenish-Westphalian Coal Syndicate, which is a company composed of most of the coalowners in that part of the country. The Syndicate regulates the production of its constituents according to the prevailing demand; it purchases the coal and coke and briquettes from them at a fixed and prearranged price, and it finds a market for the fuel and annually divides the profits among the constituents. The working expenses of the Syndicate are raised by a levy imposed on the coalowners concerned, the amount being a percentage on the invoice value of the coal, coke, or briquettes as the case may be, and the percentage always being the largest for coal. According to the Syndicate's report for 1910-11 the working expenses were £207,000, as compared with £160,000 in the preceding year, the former corresponding roughly to about ¾d. per ton of coal sold during the year. At first sight this amount would appear to be an astonishingly small sum per ton to be paid by the interested coalowners for the disposal of their production, but the cited working expenses should apparently read expenses of administration only. The actual working expenses, which are 12 per cent. of the invoice value for coal at the present moment, are about 1s. per ton, as is shown by the report of the Steinkohlenbergwerk Eintracht Tiefbau for 1910, which raised 510,000 tons of coal and paid 510,000 marks (£25,500) to the Syndicate in the form of the percentage levies for that year. As the same levies apply to the other constituents of the Syndicate, it would seem as if the total sum of over £3,300,000 was provided by the coalowners in this way for the disposal of 67,960,000 tons of coal in 1910. On the other hand, the domestic coal consumers complain of the high prices charged by the Syndicate and its associated undertakings, and from this point of view the Syndicate, whatever it may have done for the coalowners, has been unfortunate for a large section of the coal-consuming public. The system pursued in Rhenish-Westphalia was suggested for adoption in South Wales several years ago, but it was then found to be impracticable. It is scarcely likely to commend itself to the Scotch coalowners at present, whilst at the same time the method would be detrimental to the interests of consumers in general if it could be carried into effect, which is extremely doubtful.

INSTITUTION OF CIVIL ENGINEERS.

CONFERENCE ON EDUCATION AND TRAINING OF ENGINEERS.

No. I.

THE Conference convened by the Institution of Civil Engineers to discuss matters connected with the education and training of engineers opened in the hall of the Institution, Great George-street, S.W., on June 28th, under the presidency of Mr. Alexander Siemens. The Conference, as already indicated in the programme published in our columns, was divided into three sections. Sections I. and II. were devoted to scholastic and educational questions, whilst Section III. discussed problems of practical training.

The President, in opening the Conference, stated:—It is my pleasant duty to welcome, in the name of the Institution of Civil Engineers, not only members of the Institution, but also a number of distinguished visitors interested in the subject of the education and training of engineers, which is to be discussed at the meetings of this Conference. Thanks to the great Imperial gathering attracted to London by the Coronation, we are fortunate enough to see among us representatives from all parts of the Empire, who are familiar with the great variability of engineering problems under different conditions of climate and of development of the material resources of a country. Their experience will be of the greatest utility during our deliberations.

In calling this Conference together the Council have endeavoured to define the scope of discussion by declaring its object to be—"To consider the methods of preparation to be adopted by those who contemplate entering the engineering profession in compliance with conditions laid down by the by-laws for election into the Institution." The arrangement of our meetings is therefore based on the requirements of the by-laws, which demand that a candidate should possess:—(1) A sound general education, developed upon lines suited to subsequent scientific study; (2) a competent knowledge of those branches of science which form the basis of engineering; (3) practical training under actual engineering conditions. In addition, there is the necessity common to all professions, which Professor Max Müller, in his first lecture on the Science of Language, defines as follows:—". . . no science and no art have long prospered and flourished among us unless they were in some way subservient to the practical interests of society . . . that interest depends on the practical advantages which society at large derives from these scientific studies." Applying this principle to the problem submitted to this Conference, it may be expressed by saying that a young engineer should be educated so as to become a dividend-earner for his employer, for this is the most reliable indication of his merit, and the corresponding reward will not be wanting. For the same reason he should possess some knowledge of business methods and of law, not with a view of becoming his own lawyer, but in order to be able to judge when legal advice is needed. Besides all these requirements, he will find one or more modern languages very useful for obtaining remunerative employment, as the value of his services is thereby increased in the estimation of his employer. The omission of this "business" aspect of education should not be taken as a sign of its unimportance; but owing to the very short time at our disposal, the Council considered it desirable to indicate the lines to be followed by asking a number of prominent men to open the discussion on definite subjects in the three sections of the Conference, all of which have a direct bearing on the question of so instructing young men as to fit them to take part in the design as well as in the control and direction of engineering works. It is hardly necessary for me to insist on the value of proper training for engineers after what I tried to demonstrate in my address last year, that modern civilisation owes its characteristic features to the success of the engineer in improving communications and in superseding manual labour by mechanical power. There is every indication that people more and more realise to what degree the conditions of living comfortably, according to modern ideas, depend upon the work of our profession, and the interest taken in this Conference is a sign of the serious view that is taken of the importance of its object. We may accept as a conclusive proof of this the fact that the Right. Hon. Lord Pentland, Secretary for Scotland, and the Right Hon. Walter Runciman, President of the Board of Education, have kindly consented to act as vice-presidents of the Conference. Whilst it is not proposed that definite resolutions should be arrived at by the Conference, but that it should be simply a means of forming and maturing the views of those interested in the subjects brought forward for discussion, the Council have felt that it would be desirable to give the widest and most immediate publicity to the proceedings of the meetings, and have accordingly invited the attendance of representatives of the Press to the gatherings. In this respect, the course taken differs from that adopted for the professional discussions of the Institution, which, of course, in their complete form, include criticism by correspondence on the part of members all over the world. These aim at securing a deliberately considered and permanently reliable statement of matters connected with engineering practice; which, it is felt, can only be arrived at in a satisfactory manner by the procedure adopted for the Institution's own publications, of having all reports and criticisms fully revised by contributors before they are published. In the present case, however, the exchange of views which it is the purpose of the Conference to promote, is not subject in any such degree to the foregoing considerations, and as the object is rather to form opinions than to arrive at and to record definite conclusions, the Council are pleased to know that the Institution will be assisted and supported very materially in this Conference by the Press. Letters were received from Lord Pentland and Mr. Runciman expressing their regret that they were unable to be present owing to a Cabinet meeting having been called.

Sir W. White said he had been asked by the President to make a short statement on the steps which had been taken by the Institution in recent years in connection with the education and training of engineers. The first step was that taken under the presidency of Sir John Wolfe Barry, and the second was made under his own presidency when a representative committee of engineers on education was formed. The third step which was now to be taken naturally followed upon the revision of the by-laws and regulations of the Institution. It was necessary to look at the subject from quite a broad standpoint, but the attempt made by the Committee of which he was chairman, and by others associated with the work, represented an endeavour to put the training of the young engineer on what they believed to be sound lines. In this connection it was necessary to remember that what was done was being done for the benefit of the average student. There was a tendency to forget that the average student was the man who had to be provided for. The exceptional man who, like Lord Armstrong, was an engineer by necessity, and the man who found his way up from the humblest rank to the highest position by sheer ability, those men were well able to take care of themselves. They were met to reconsider the whole position of the general education and scientific and technical training of the engineer. He was among those who thought that the danger of excessive encroachment from the scientific side was now a very considerable one, and he desired to emphasise the absolute necessity for a full practical training. There was no doubt that for a long period in the past the methods of the British engineer were less scientific than should have been the case, but that period had gone by, and there was now some danger of the undue exaltation of the scientific side of the industry. The decision which he hoped would be reached by the Conference would endeavour to touch the golden mean.

Sir John Wolfe Barry said he would like to add a word or two to what had fallen from Sir Wm. White. He was heartily in agreement with the statement as to the necessity for the engineer to receive the best practical training. He himself was President of the Institution when the examination system was first set on foot, and the work that was taken in hand at that time he believed had a good effect in bringing about a general recognition of the necessity for the scientific training of the engineer which up to that time had been very largely non-existent. However, although that was an essential part of the training of the engineer, no one could doubt, and he felt very strongly on the point, that there was a need for the engineer to receive a sound general education and culture, and he was glad to note that in the paper which was being read by Dr. Gow, the headmaster of Westminster School, form and substance was being given to that view.

The meeting of Section III. was then opened in the main hall of the Institution.

Mr. A. J. Lyster presided over the general meeting of Sections I. and II. in the Library, which followed the opening of the Conference. His opening address was as follows:—

Having regard to the objects of our meeting here to-day, I feel sure that you will not think I am guilty of any exaggeration when I say that the Conference we are entering upon is one of the most important which the Institution has undertaken, and I congratulate those who have been responsible for its initiation upon choosing a matter of such material interest for the welfare and advancement of the profession. Those who have at heart its best interests—and I am sure I can include amongst them all the members of this Institution—will agree that the general education of young men desiring to become engineers, with which subject Section I. of the Conference deals, requires the closest attention of those who on the one hand realise what the necessities of the profession demand, and those, on the other hand, who control the selection and organisation of education; and so it seems very fitting that, in contradistinction to the too prevalent practice of "muddling through," the heads of our universities and public schools should meet the members of the profession and discuss with them the best preliminary training for those who are hereafter to uphold its traditions. The Institution itself has done much in recent years towards ensuring that all its members shall have a suitable intellectual equipment, which will not only qualify them for their membership here, but will be of advantage to them in the practice of their profession, and the by-laws of the Institution have been modified with the object of securing this end; but these efforts, to obtain the best results, require to be supplemented and supported by the action of University and school authorities. It will probably always be a disputed question at what period specialisation shall be entered upon, and to what extent it shall be carried, in the preliminary education of the would-be engineer; but I am sure we all agree that some specialisation is essential at some period or other, and that the young man who has made up his mind to enter the profession should have his education sooner or later directed towards those special subjects which are likely to be of most use to him in his work. At the same time I feel certain that everybody will equally consider it a most undesirable thing that an engineer should be a mere one-sided creature, with no other intellectual equipment than a knowledge of the special subjects to which he would hereafter have to devote his attention, and that any system of education which produced such a result could not be satisfactory. Education to be of real value should, I take it, not only furnish information and knowledge, but should also train and expand the intelligence and develop that type of character which fits a man to lead the best and most useful life, and all subjects and methods which can produce this result should be included in the curriculum of University and school life. It must be remembered, however, that a great many of these institutions were founded and organised in days when the conditions of life were very different from what they are to-day, and certainly much less strenuous, and when competition, both individual and international, was much less keen. The choice of professions, too, in those days, was much more limited, and so the curriculum established was one which lent itself much more to the development of scholarly culture than to the practical requirements of those who to-day have to fight the keen battle of life. With an ever-increasing intensity of struggle, and with the developments of science ever enlarging its boundaries and multiplying its complexities, the demand for special training for the engineer becomes increasingly urgent, and unless he is to be debarred from our universities or public schools, it behoves the authorities to bring their educational standards into line with modern requirements. As I have said before, we are very far from wanting the members of our profession to be engineers and nothing else; on the contrary, we want every opportunity given to the best type of man that the University and public school can produce to start with the best intellectual equipment as an engineer. Much has been done in the immediate past to bring this about, but there still appears to be much left to do, and this Conference has been inaugurated with the view of exchanging and focussing ideas on the subject between the authorities on either side. A year or two ago I read a speech by the head master of one of our public schools, in which he was at pains to defend the restricted form of education in vogue at his school, and his defence might be summed up in this, that inasmuch as there was no lack of applications for admission to the school, there could not be much wrong with the education given there. Well, gentlemen, if our Conference produced no other result than to condemn that spirit, we should at least not have met in vain. But

we require, and I think not unreasonably, something more; we want, added to all, the peculiar advantages that the University and public school can give, an education which more especially fits the young man for the career in life for which he is destined, and which in the case of engineering comprises a profession of rapidly increasing importance, and one more closely than ever before associated with our national progress and prosperity. I have endeavoured to make these introductory remarks as general as possible in order to avoid encroaching on the province of those who have kindly undertaken to address us more precisely on the subject, and who are better qualified to deal with its particulars; and to them I will leave the responsibility of defining how and where the boundaries of the general and special forms of education should be fixed.

Dr. J. Gow then presented his short paper on "Literary Education and Engineering," and Professor Silvanus P. Thompson presented a short paper dealing with the extent to which mathematical and scientific subjects should share with other subjects of literate education the attention of schoolboys who intend later to enter the engineering profession.

Literary Education and Engineering.

By Rev. James Gow, Litt.D., Headmaster of Westminster School.

Some six years ago I was asked to undertake the office of examiner in Latin for the Institution. From my own experience at that time and from the statistics of subsequent examinations, I may fairly infer that Latin is seldom included in the preliminary education of an engineer, or that boys who intend to be engineers pay little attention to this subject; and it is probable that, where Latin is neglected, no very close study is given to any other language. I propose to argue that a literary education up to a certain point, which I will define, is of as much value to the engineer as to anybody else; and that, at least in the higher walks of his profession, he is likely to be injured by the want of it.

I do not contend that literary studies are of any direct or immediate use to the engineer. His work must be largely deductive and mathematical, on which a literary education has no bearing. But presumably there are occasions when he is called upon to make use of chemistry or geology, or some other inductive science, and he is not properly equipped unless he has a fair knowledge of these sciences. Now it is notorious, at least to schoolmasters, that a boy who passes from the classical side to the modern side of a school has an immense advantage in inductive science over those who have been educated entirely on modern lines. Latin, as we teach it, with grammar and dictionary, is inductive science almost in the abstract. A page of Cæsar is, as it were, a large collection of specimens, each of which has to be parsed, *i.e.*, classified under numerous heads. And along with this process of analysis there goes a process of synthesis which can hardly be matched with any other material. With words for his subject, the teacher can say "Construct me a word which has the following six characteristics," and no similar exercise can be set at so early a stage in any other study. Language is thus incomparably the cheapest and the most rapid introduction to inductive science; and a boy who has had a thorough drilling in Latin has acquired orderly habits of mind which make inductive natural sciences easy to him.

Secondly, the engineer is doubtless often called upon to command a gang of foreign workers. The sooner and the better he learns their language the more easily he will control them and direct their labour. The language, of course, may be wholly alien to any that is spoken, or ever was spoken, in Europe; yet the necessary elements of language must always be the same. There are things to be named and relations between them to be indicated, and the man who, by training, is alive to this fact and on the watch for these elements, has a great advantage over another who learns at haphazard. Anybody who has read Colonel Patterson's book "The Man-eaters of Tsavo," will remember how nearly he was killed by his own coolies, and how he saved his life by some timely eloquence. Probably many an engineer has had reason to regret that he could not speak the language of his labourers.

Thirdly, though it is perhaps not the business of the engineer to make contracts, it is undoubtedly his business to understand them and to give and receive orders accordingly. These transactions require a careful and exact appreciation of words by whomsoever used. It is too often forgotten that the whole profession of lawyers lives in the main on the inability of other people either to say what they mean or to understand what is said to them. The business of the conveyancer is to draw important documents in the sense required, and most of the important litigation between honest people turns on some ambiguity in an Act of Parliament or a will or a contract. The larger the interests in which the engineer is concerned, the more necessary it is that he should study his instructions closely and be quick to discern a verbal difficulty.

Hitherto, I have spoken only of linguistic education, but something also should be said of literary studies proper—the world of books, poetry, history and the rest. The engineer, in Europe, and I suppose also in India, China and other countries which have an ancient civilisation, is frequently called upon to deal with places and things which have artistic merits or historical associations that endear them greatly to the general educated public. The French proverb which says, "Rien n'est sacré pour un sapeur," implies that, in France at any rate, the engineer has not always been tender to such sentiments, and even in England—perhaps even in London—there may be found monuments of engineering skill which many people would wish away. But of late years the general educated public has become much more numerous and more highly educated, and I suspect that a time is at hand when it will be advantageous to the engineer to mingle the *utile* with the *dulce*, to discern not only what is mathematically possible but also what is artistically impossible; not only what is cheap, but also what is nasty. For this purpose some general culture is necessary, some critical faculty, some pleasure in beauty, some habit of reading and delight in reading such as makes a man liberal in mind and sympathetic to the common run of his fellows.

And this same culture which keeps a man from being a prig may also serve to keep him from becoming a beast. I suppose that an engineer has as much leisure as other folk, and it is just as important to him as to them what use he makes of his leisure. Most of the mischief that is done in life is done in leisure, and the rational employment of this time is the real object of general education. To be happy with a book, to know a good book from a bad one, to be able to read a first-rate book over and over again, finding new pleasure in it every time—the man who can do this is master of himself and saved from a hundred base temptations. To these temptations, I imagine, the engineer is peculiarly liable, since he is so often lonely in a far country and a cruel climate. Many of you must know instances of young men who have gone to the bad in such conditions, and who might have been saved if they had had more resources in their minds and had known what to do with themselves when they were off duty.

But you may say to me that, even if I have proved my case, I have proved too much, and a man who is to have all the education that I want to give him will never have time to become an engineer at all. But, in reality, there is no fear that literary culture will absorb too much time. Against that danger there is a very efficient safeguard. The boy who is going to be a first-rate engineer will not take any more literary education after the age of 16 or thereabouts. Until that age clever boys are almost always equally clever at every subject, but at 16 their tastes begin to be pronounced and their minds cease to be receptive except in one particular direction. Parents are seldom awake to this fact. They see a clever little boy amusing himself with a toy engine, or making an aeroplane, or interested in motor cars, and they assume that his ultimate bent will lie that way, and trundle him off to the modern side or the engineering school. It is a mistake to be in such a hurry. The best plan, I am sure, is to give a boy a general education, mainly literary, up to 16, and at that point to watch him closely, and put him to what he wants to learn. If he is clever, he will be successful; if he is not clever, he will at least be happy and proud of his calling.

On the Extent to which Mathematical and Scientific Subjects should Share with other Subjects of Literate Education the Attention of Schoolboys who intend to enter later the Engineering Profession.

By Professor Silvanus P. Thompson, D.Sc., F.R.S.

For the purpose of initiating a discussion on this subject the writer has chosen rather to set down a few salient debatable points than to utter platitudes that would meet with general agreement. If the result seems disconnected and provocative the reason is self-evident.

In the present chaos of secondary education, the schools of the type which chiefly furnishes boys to the engineering profession are almost wholly destitute of any organisation adapted to that end. From the oldest, such as Eton, Harrow, and St. Paul's, down to the newest secondary schools established by the County Councils, not one, so far as the writer is aware, has any definite educational goal to set before the majority of its boys. Some schools aim definitely at preparing a handful of their scholars for Sandhurst, for Woolwich, for Junior Civil Service competitions, for University scholarships, for conjoint board examinations, or for matriculation at one of the Universities. But these aims are for minorities of the scholars. Is there in all London, nay, in all England, a single school which has a definite educational aim towards which it focuses the training for as many as 50 per cent. of its scholars? In general, schoolmasters devote their energies to preparing a few scholarship candidates, and have no definite educational aim whatever for the bulk of the boys. Until this hopeless state of things is radically altered, and until the goodness or badness of a school is adjudged not by the triumphs of a few, but by the proportion of all its scholars whom it brings to a maturity test, British education will continue to be in a bad way.

Contrast this state of things with that which exists in the secondary schools all over Central Europe. Austria, Prussia, Bavaria, Switzerland, and even Denmark, are vastly ahead of us here. In all German secondary schools, whether of the Gymnasium, the Real-Gymnasium or the Oberrealschule type, there is a perfectly definite goal before every boy in the school. Before he reaches the Ober-prima, or topmost class, he will have to pass the "Einjährige" examination, or pass out disgraced; and it is his ambition and that of his master that he shall pass not only this, but also the Abiturient or maturity examination some three years later. If he passes the Abiturient examination of his school—an examination held in his school by co-operation of his teachers with the Government commissioner who comes to conduct it—the way is open for him to any University and to any professional career.* If the German boy fails to pass the maturity examination of his school he is marked as unfit for professional life. The Universities are closed to him. The Church is closed to him. The higher Civil Service is closed to him. He cannot become barrister, solicitor, physician, surgeon, veterinary surgeon, architect, engineer, surveyor, patent agent or accountant.

The immense advantages of this reasoned organisation of the secondary schools can hardly be overstated. A good systematic secondary education is guaranteed to the majority of the boys. A master who might neglect the interests of the majority to specialise on a few clever boys is at once discredited. The test is really a test of the quality of the school. It does not depend on the fashion or the prejudice of a University board. The State, co-operating with the school, sets the standard and decides whether the school is efficient or not. Throughout Prussia, Bavaria, Austria, and Switzerland, the Universities have long ago abandoned reliance on their individual matriculations, and accept the certificate of Abiturient; they preserve, it is true, a matriculation test, but only for exceptional cases.

Here, with us, the State has not yet—save in Scotland—organised the secondary schools. Each university wastes its energies over holding matriculations and the like. Almost all the professional bodies, such as the Law Society, the Institute of Actuaries, the Society of Apothecaries, also hold amateur matriculations or preliminary examinations of their own to test the general education of candidates for entrance. The result, educationally, is muddle, waste, inefficiency. The schoolmasters, in despair at the multitude of twenty conflicting matriculations, fix upon none, and let chaos work. On this they are agreed: that of all the matriculations that of London University is the worst, the most doctrinaire in its requirements.

Eight years ago the Institution of Civil Engineers appointed a committee, under the chairmanship of Sir William White, to consider and report on the best methods of training for all classes of engineers. After 2½ years their report, affirming both the present system of studentship examination in matters of preparatory education, and that of the examination for associate membership, was adopted by the Institution. The recommendations in respect of preparatory education, contained in pages 8 to 10 of the committee's report, state admirably, from the point of view of the engineering profession, the requirements toward which the schools should be organised to work, though the standard suggested is scarcely up to that of the Abiturient examination of a German school of corresponding type. Four points in these recommendations may claim attention here:—(1) Specialisation while at school, that is to say, up to about the age of 17, is undesirable. (2) "A leaving examination for secondary schools, similar in character to those already existing in Scotland and in Wales, is desirable throughout the United Kingdom. It is desirable to have a standard such that it could be accepted by the Institution as equivalent to the studentship examination, and by the universities and colleges as equivalent to a matriculation examination." (3) Instruction in mathematics should be by somewhat modified methods. (4) A general knowledge of elementary physics and chemistry, or natural philosophy is preferable to the pursuit in detail of some particular department in science.

With this last recommendation the writer finds himself in hearty agreement. Many mistaken notions are abroad as to science teaching in schools. Excellent as was the notion to give science a place in the school curriculum, the pressure put upon schoolmasters to introduce science subjects has had some strange results. The writer knows of one school where the "chemistry" taught twice a week consisted in making the boys "get up" a chapter from Roscoe's Elementary Lessons without their ever making, or even being shown, a simple chemical experiment. On the other hand, the heuristic method—a method used in due place by every good teacher since the days of Socrates—has been absurdly pressed, even to the detriment of progress. There can scarcely be anything more dreary than a forced heuristic lesson by a teacher who has neither inspiration nor sympathy. For at school the first object of science teaching should be to evoke interest, not to impart the facts or data of science, still less to systematise their re-discovery. All that has its place later. The fossilisation of science teaching is indeed the thing now most to be feared. A lesson on the microscope, followed by an hour's excitement in examining or making slides; a talk about the telescope and the wonders it reveals, with an actual instrument to see and handle; a chemical chat about oxygen, followed by a few fireworks; all these will be of absorbing interest to intelligent boys of 12 or 13. After that a few more systematic lessons will attract, without exhausting the attention of the hearers; and the chance of reading some of the more attractive boys' books of science will be eagerly grasped. Elementary mechanics, the foundation of all engineering, can be made thoroughly attractive by a live teacher who handles his subject in a human way; and he will lead his boys readily from experimental fact to deduced principle, and from deduced principle to simple calculations, which can, again, be verified by experiment. The laws of forces, of the combinations of forces, of balanced forces, of oblique forces; their applications in the case of levers and pulleys and kindred mechanism, will be a delightful change from the dreariness of history or the grind of grammar. The bad teacher, of course, can make even electricity as dull and distasteful a subject as the conjugation of irregular verbs. Not until a boy is 15 or 16, and is approaching the stage of matriculation, should science be allowed to degenerate into a grind. The stimulus of the approaching examination will carry him through the drudgery; and the amount of drudgery will be felt to be small because of the interest already acquired in the subject itself. It can hardly be too strongly urged that any specialisation in scientific subjects before that stage has been passed is essentially out of place and harmful.

Reverting to mathematics, it may be remarked that a great change has already come over mathematical teaching during the last ten years. This is partly due to the general discontent with the bad methods in vogue, partly to the strenuous crusade undertaken by Professor Perry and other reformers. The recommendations of the Institution Committee of 1906 have already been widely adopted in the schools. They are worth recalling:—"Instruction in mathematics should be given by methods differing considerably from those usually adopted in the teaching of this subject merely as an intellectual exercise. The geometrical side of mathematics should be fostered, and before they leave school boys should be conversant with the use of logarithms, and with at least the elements of trigonometry, including the solution of triangles. It is also of importance that instruction in practical arithmetic should be carried further than has been the case hitherto, with the object especially of encouraging the use of contracted methods and operations in mental arithmetic. . . . Special attention should be given to drawing; the instruction should include ordinary geometrical drawing, with orthographic projection, curve drawing, freehand drawing, and practical mensuration."

One difficulty, which has been explained by masters of progressive tendencies in the promotion of sensible reforms such as these, has been the stupidity of inspectors who have not yet grasped the importance of them. The writer is cognisant of a case—anterior to 1906 it is true—where the head of a school who had taken great pains to reform the arithmetical teaching on the lines of Sonnenschein's arithmetic, particularly in the introduction of contracted methods, was amazed to find that the inspector disallowed all the answers worked on this plan! The benumbing influence of the older Cambridge traditions is also felt. The writer came across a case in his own experience where an experienced master—a high wrangler in his day—who was employed as private coach to a rather backward student in the Technical College, indignantly refused to give him—as it was suggested he should—some exercises in plotting curves from equations, on the ground that it was not his business to teach practical mathematics. Bad teaching is responsible more than anything else for distaste for mathematics. A really capable teacher will make his boys enthusiastic over matters that in the hands of others are deadly dull. A class can be made—the writer has seen it happen with students of seventeen or eighteen—wildly excited over Bessel's functions, and a class of young boys has been known to sit up late in the pursuit of finding out all the prime numbers that occur between 1000 and 2000. If mathematical teaching is dull, it is the fault of the teacher.

Of all the changes that have come over the teaching of mathematics the greatest is the almost complete disappearance of Euclid. Theoretical geometry is now taught on other lines. But the writer is not sure whether the loss is not greater than the gain. Euclid in the hands of an uninspired teacher was probably the worst possible way of teaching geometry—the worst, because it was too often attempted with boys who had not previously learned any geometrical drawing, and had therefore no conception as to what it was all about, and because the way in which the subject was treated was often merely to learn by rote something that neither the teacher nor the taught really understood or valued. But the teaching of Euclid was in one respect absolutely invaluable. If it is approached rightly, after practice in geometrical drawing, which familiarises the learner with the concrete facts, the study of Euclid constitutes an unrivalled training in methodical and cogent reasoning. The great charm and value of Euclid's presentation is the way in which one proposition hangs logically upon another. Sequence and sustained cogency of argument are the vital matters. The bad teacher ignored all this, requiring only verbal accuracy in memorising details, and brought disrepute on the finest mental discipline ever introduced into education. But Euclid is gone, and there has been nothing put in its place. It is the writer's deliberate opinion that boys now-a-days are less capable of following a sustained train of thought than they used to be. The mental discipline of the chain of connected thought is strange to them. There may be other causes also, but this is assuredly a cause.

It may be that in the evolution of literate studies, particularly in the teaching of the analysis of sentences and in the logical composition of exercises, some equivalent discipline may be found. But it is doubtful whether in the study of English in the schools as much attention is given to analysis as was the case ten years ago. Every educator interested in maintaining a good balance in the subjects of preliminary education will surely agree that while premature specialisation, whether in languages or in science, is to be deprecated, boys must be trained in thinking and in the expression of thought. In the conflict of subjects one is apt to lose sight of the fact that training in thinking and in the correct expression of thought is more essential than the study of any particular subject, whether Greek or geometry. It is, after all, not so important whether the hours per week given to science should be a few more or a few less, as that in all studies—science, mathematics, language or literature—there should be cultivated precision in the use of words and cogency in modes of thought. These things are more important in the long run, and vastly more important in the ultimate making of a professional engineer, than the acquisition of a hoard of scientific facts. The secondary school must not degenerate into a house of cram.

Sir J. Wolfe Barry, in opening the discussion, said that there would be a general agreement on the statement with which Professor Thompson concluded his paper, that the secondary school must not degenerate into a house of cram. There would also be a consensus of opinion on the statements made as to the importance of training the minds of boys, and that they should not be allowed to specialise at too early an age. The only question which seemed to arise between the two papers was how much time should be given to the different subjects. Dr. Gow, who spoke with unrivalled knowledge, expressed the opinion that for the training of the mind the science of languages was a most valuable aid. He did not think anybody who had experience of the subject would doubt the truth of that statement. Dr. Gow also put in a plea for the advantages of a general literary training. To that extent he was in entire agreement with him. He had noted a tendency in secondary schools to force the pace too much up to the age of sixteen. It had been said that it did not very

* Except a military career, which begins earlier in the cadet schools. Abiturienten can, however, be admitted to the "Offizierkorps" if possessed of the proper qualities of birth and sentiment.

much matter what particular language was taken from the point of view of training the mind, but it appeared to him that German would prove as useful in that respect as Greek or Latin. There could be no doubt that the study of history would prove most valuable to the young engineer, as there were engineering methods in the old civilisations from which much could still be learned. He doubted whether there was up to the age of sixteen sufficient time for a boy to undertake so much study as was suggested by Professor Thompson, but there would be general agreement as to the necessity of bringing about uniform standards at the schools. With regard to the four propositions put forward in regard to the training of engineers by their Institution eight years ago, those propositions met many of the criticisms which had been made. Nothing had happened since that time to show that these conclusions were not justified. He would like to emphasise the need of making engineers something more than engineers, and giving them when they were in the student's stage the advantage of that culture which could not be secured in after life.

Mr. Theodore Reunert (Johannesburg) said that he had been associated with Lord Milner in the attempt to re-organise higher education in South Africa. There was a feeling of disappointment in some minds at the practical outcome of the last conference on engineering education, and it appeared to him that there was too great a disposition to leave those in charge of the education of students to follow their own course. Undoubtedly there was a great difference of opinion as to what was actually the best system of training the engineer, and as to whether practical work should precede a certain amount of technical college training. What was needed was that the Conference should have the courage once for all to lay down rules of study and training for engineers, and if that were done the engineer would at last take rank with those in the other professions in which the course of study to be followed was, as a rule, made quite plain. He believed that at the present time the Institution of Civil Engineers had a great opportunity before it of setting up a distinct system of study for those desiring to enter the profession. In one of Mr. Matthew Arnold's reports it had been stated that the thing to have in view was that everyone who presented himself for the exercise of any calling should have received over a certain length of time the best preliminary training for that calling. That was not an absolute security for exercising that calling; but, as Matthew Arnold had urged, it was at least the best security, and was a thousand times better security than the mere examination test, upon which with such ignorant confidence we had been inclined to lean with our whole weight.

Dr. W. H. D. Rouse contended that while to a certain extent the schoolmaster was the expert and the parent the non-expert, in questions of principle the parent might and should exercise a very distinct influence upon the course of study. In his experience the schoolmaster was subjected to the enormous pressure of uninstructed public opinion, and the organised public influence of local bodies, formed very often of the most uninstructed section of the community, as well as to the strong pressure of examination for university matriculation and other devices of the devil. Dr. Thompson had referred to the method of conducting examinations in this country. Those examinations were playing mischief in the education system of this country, not because of their number, but because the examinations themselves were bad. While some of the examinations for open scholarships at universities were of a wide and open type, matriculation examinations and the Oxford and Cambridge local examinations were hotbeds of cram, and he could quote an instance where, on the same level for examination purposes, were grouped higher mathematics, Greek, hygiene, and Esperanto. He did not think that any really intelligent method or plan of instruction could be carried out in schools in which the teaching staff had to bear in mind the pressure of these local examinations. No examination, in his opinion, could be helpful unless it was carried out in conjunction by the State or some outside body and the teacher.

Mr. William Whitaker agreed as to the advantages of language study for engineering students. He would like to emphasise the importance of an early training in mathematics in connection with the development of reasoning power. While the details of that study might be lost, the mind training remained with the student.

Dr. R. M. Walmsley contended that the fault did not rest entirely with the schoolmaster; in his opinion, the blame for the present want of aim in education was largely with the parent. Reference had been made to the pressure put upon the schoolmaster by uninstructed public opinion, and he believed that the difference between education in Scotland and England was largely due to the difference in the point of view to the parent. It was necessary to instruct the general public as much as the pupils in the schools, as without the support of public opinion the schoolmaster was beating the air. He did not hold any brief for the London University matriculation examination, but bad as that examination might be, all they could get from the public was destructive criticism. He would point out, too, that if that examination were given up, the London University would soon be short of funds, as the support given by the State at the present time was so small, that without the fees derived from the examination the London University would be bankrupt. It was a public scandal, but he hoped a way out would be found.

Mr. Stanley De Brath pointed out that the Royal Geographical Society had taken steps to encourage the study of geography in the schools, but it was found impossible to follow the suggested course in our public schools, for the simple reason that the foundation which the Royal Geographical Society assumed to have been laid in the preparatory school did not in fact exist. The defects of preparatory schools were at the bottom of a good deal of the dissatisfaction which existed on the subject of school training. In connection with the proposal made in the report of the Royal Commission on the training and education of officers for the army, suggesting a knowledge of English literature and French and German, among other subjects, the War-office had found such difficulties in carrying out that proposal that it was under consideration to establish schools for the special purpose of educating officers in those subjects. The reason for the chaos and want of system was the neglect in the early years of training.

Professor W. S. Abell said that an important point was that the engineer should be taught to think dynamically. There was a tendency at the present time for the problems which had to be dealt with by the engineer to be solved statically. He desired the engineer to regard problems rather from the considerations of working energy than from the considerations of force acceleration. Much trouble arose from the fact that the educational aim had not been definitely settled, and he hoped that the Conference would formulate definite principles for the education of engineers. With regard to the teaching of Euclid, that was the basis of the English system of applied mathematics, while the continental analytical system was quite different, and if the teaching of Euclid was dropped in our schools the English system of mathematics would be placed at a great disadvantage.

Colonel J. E. Capper was of opinion that the real point of the whole matter was to be found in that part of the President's opening address where he referred to the need of instructing the engineer to fit him to take part in the physical solution, control, and direction of engineering work. The engineer should be fitted to enter into the discussion of all economic questions which arose in connection with his work. It was found at Chatham that the more diverse subjects which were taught the better for the student, and that the real engineering education only commenced when the student began his practical work. The object of the schools should be to fit the student for his work by a general all-round education.

Mr. T. H. Bailey insisted that the object of the public schools should be to give a good general training of a character which would enable the boy to take up any particular profession afterwards.

Dr. Gow, replying on the discussion, expressed the hope that the Institution, in taking fresh steps in connection with the education of engineers, would not start any new rigid examination. It had been suggested that the public schools had no real aim. The schools were not responsible for the existing state of opinion, which was largely due to the number of examinations held by all classes of profes ional societies, for which boys had to be prepared. He did not complain of the fact that the Institution of Civil Engineers held its own examinations, but he did not think it desirable to make an entrance examination a *sine qua non* if some equivalent examination had been passed. The schools would give attention to the requirements of the Institution with regard to particular subjects, but they required guidance in the matter.

Dr. Thompson said that at the present time a departmental committee of the Board of Education was sitting on the question of organising a national system of maturity examinations for the schools, and until that report came out it was unlikely that any other body would move in the matter. He agreed as to the necessity of the proper teaching of English, and associated himself with Dr. Gow in his plea for the simplification of examinations, and the need that the Institution of Civil Engineers should recognise other examinations in lieu of its own.

Mr. Alexander Siemens said that that was the case at the present time.

Professor A. K. Schwartz then presented his paper.

THE QUESTION OF SPECIALISED ENTRANCE EXAMINATIONS FOR UNIVERSITY OR COLLEGE COURSES OF STUDY IN ENGINEERING SCIENCE, WITH A VIEW TO THE CURRICULA TO BE FOLLOWED, AND ALSO OF THE INCLUSION IN THE LATTER OF COURSES IN MODERN LANGUAGES.

The subject of this note involves a consideration of the relations subsisting between the curricula of our secondary schools and those of our engineering courses; or, more broadly, of the relation of general to specialised education. In the preface to his treatise on the Parts of Animals (Περὶ Ζωῶν Μορίων), Aristotle states very clearly what in his opinion should be the aims of these two important phases of education:—"An educational course of study should have as its aim one or other of two distinct degrees of proficiency in the acquirement of the various branches of knowledge or science. The first is the more thorough and special knowledge of the man who has to take part himself in the advancement of a branch of science—to become, in fact, a professor or expert. The second is, on the other hand, the more limited degree of knowledge which should be attained as a feature of a general education."

The lapse of more than 2000 years, with the immense increase in the sum of human knowledge which it has brought, has increased rather than diminished the cogency of Aristotle's dictum. We may define the functions of the secondary school and of the college course as follows:—(*a*) The function of the secondary school is to give a liberal general education, that is, to impart a limited amount of knowledge, in a range of subjects so selected and dealt with as to develop the mental faculties in a comprehensive manner. (*b*) The function of the college course is to impart a certain amount of knowledge of a specialised character, and to train and develop further the mental faculties along specific lines. The function of the entrance examination for university or college courses in engineering science may be taken to be the determination of the fitness or otherwise of the candidates to pursue the contemplated course of specialised study.

This question of fitness may be regarded from two standpoints as representing:—(1) A satisfactory standard of general education. (2) In addition to a general education, a satisfactory standard of attainment of a specialised character in subjects germane to engineering science. In the writer's opinion the matriculation examination of a university should follow the first of these alternatives, as it should be essentially a test of general education, and should admit to all Faculties. The governing bodies of the leading professional societies, however, have exhibited a growing tendency to call for some degree of specialisation in the matriculation examinations. Hence the special obligatory subjects or higher papers frequently demanded—in addition to the ordinary subjects of the matriculation examination—to qualify for entry in the Faculties of Law, Medicine, or Engineering. Similar conditions are frequently imposed in the entrance examinations to courses in engineering science in colleges which are not constituents of universities.

These special demands have to be met by the secondary schools. The secondary schools in this country may be divided into four groups or classes, as follows:—(1) The large endowed public schools; (2) the grammar schools and smaller endowed schools; (3) the rate-maintained or council schools; (4) the private and proprietary schools.

In schools of the first and second types there is a sharp division between the classical and the modern or science sides; in the remaining types of school this division is not so marked, but there is usually a choice of subjects allowed in the upper forms which gives either a classical or a modern bias to the curriculum of the final portion of the school course. The minimum age for entry at the universities in this country is 16, in America it is 17, and in Germany it is 18 years. Sixteen years is also the minimum age for entry to most of the college courses in engineering science. The average boy of 16 years of age who has had a liberal general education is not usually in a position to negotiate successfully these specialised entrance examinations; he therefore extends his school course, the final portion of which is therefore devoted to "preparing" him to meet the requirements of the examination market, or for the special requirements of his future career.

The subjects which are in varying degree common to the college courses in engineering science and to the secondary schools are mathematics, mechanics, physics, chemistry, geometrical and freehand drawing, manual training, and modern languages. In the matriculation examinations for the universities and in the entrance examinations for engineering courses these subjects are treated either as obligatory or optional subjects. Mathematics is invariably made obligatory, and the standard of the examination in this subject should therefore be such as may be compassed in the course of a liberal general education on either the classical or the modern side of a secondary school.

The science subjects selected for tuition in the secondary schools vary in different schools, and this fact is recognised in the matriculation and entrance examinations by giving an option to the candidate in the selection of one or more of these subjects. The fact that these options are widely exercised renders it impossible to commence the college courses in these subjects otherwise than *ab initio*. It is evident, therefore, that the treatment in the secondary schools of science subjects other than mathematics must be regarded as having an educative value rather than an instructional one.

The object of teaching modern languages in the secondary schools at the present time is not so much the investigation of the logic of language and the reflex action of its grammar on the structure of other languages—and particularly of our own—as to furnish the ability to think and speak and write in a foreign tongue. This teaching of modern languages may therefore be regarded as specialised instruction. Here again the average boy of 16 years of age falls short of the standard aimed at. For technical purposes a reading knowledge of the language is perhaps sufficient, but while the average boy, on leaving school, may be able to read a scientific French work with the aid of a dictionary, he is usually quite unable to deal fully successfully with a German work of a similar character. Instruction in German, therefore, frequently forms part of the courses in the engineering colleges, and, regarded as specialised instruction, it is not here out of place.

In conclusion, it appears to the writer to be particularly necessary, in the case of the engineer, that his secondary school training should be on as liberal lines as possible, since his subsequent training in the college, the workshop, and the office is largely materialistic. In this connection we shall do well to remember Tredgold's famous definition of a civil engineer as one who controls the forces of Nature for the use and convenience of man, and to note that this definition postulates not only a knowledge of natural philosophy, but a knowledge of the humanities also.

What is wanted in the engineering courses is a supply of students with a wide mental outlook, whose faculties have been well trained and evenly developed, and any specialisation in the secondary school at the expense of this liberal training is to be deprecated. Let us bear in mind, with Emerson, that nature is not fixed but fluid, and that spirit alters, moulds and makes it. The future of the whole human race is closely bound up with the work of the engineer; we should see to it, therefore, that his preliminary training shall be in no sense a narrow one.

Mr. J. T. Jackson stated that he had traced the after careers of students of Dublin University, and his investigation went to show that the order of merit in the examinations was not in any way reflected in the positions occupied in after life. There was a marked connection, however, between the age at which the engineering courses were taken and subsequent success; those who commenced the engineering courses young had been generally more successful than those who commenced them at a later period. The entry examinations for university and college courses of training should not be too highly specialised. The object of such examinations was to ensure that the students should be of sufficient ability, and should have had sufficient previous training to take proper advantage of the courses of instruction. The examinations should not be used as a lever to shift any portion of the specialised work back from the college to the school.

Mr. W. H. Patchell expressed a view that more attention should be given to modern studies. He did not wish to under-rate in the slightest degree what Dr. Gow had said about literary education. If a boy learned Latin and Greek, particularly Latin, it would give him facility for acquiring other languages, and in this connection he would refer to the importance of Spanish, there being a tremendous field open for the Spanish-speaking engineer. More attention ought to be paid to German than was the case in this country. In respect to languages, the German engineer possessed an advantage in having acquired a working knowledge of English in his school days.

Dr. W. C. Unwin urged that some specialisation was necessary, and he referred to the well-organised German system, which possesses undoubted advantages. He had had thirty years' experience with boys coming from schools, very largely from the great public schools, to the colleges to receive technical education of somewhat higher type. The boys came to them at an average age of eighteen, and they had to go through a three years' theoretical training, and after that two or three years of practical training, before they were in a position really to earn a living wage. He did not think it was too much to expect from boys of eighteen years of age that they should have acquired a certain amount of the special knowledge necessary to the engineering course. They did not ask for a great deal of knowledge—some science, chemistry or physics up to the elementary stage, and mathematics up to the early part of trigonometry. There seemed to be considerable difficulty, under present conditions, in meeting these two conditions. Speaking from experience of Cooper's Hill and the Central College, he was unable to agree with the statement as to the after career of students made by Mr. Jackson, who dealt with Dublin. His experience, and he had knowledge of the after careers of nearly all the students of both places

mentioned, was the absolute opposite to that which had been quoted.

Professor E. W. Marchant agreed as to the necessity for a certain amount of specialisation, and he quoted Ruskin to the effect that it was necessary for a teacher to know the mode of life for which education was intended to obtain the best results. The great defect in the modern school system was to be found in the attempt to teach too many subjects. He considered that it was desirable in any school to separate the students into two main branches, those who were to enter the administrative profession, and those who were to become engineers and doctors. The education of the latter classes should be largely based on scientific knowledge, while the former class should study languages, literature, and the classics, as well as some science. He entirely agreed with the policy which appeared to have been followed by the Institution of Civil Engineers in aiming at a fairly high standard of mathematics for engineers. The trouble with the average student who went into college was that he did not know enough of mathematics.

Professor Schwartz, in reply, referred to Dr. Unwin's plea for a certain degree of specialisation in entering examinations. It had to be borne in mind, however, that the matriculation examinations of universities in different parts of the country had quite different functions to the studentship examination of the Institution of Civil Engineers. The object of the matriculation examination was to decide upon general knowledge, and he personally deprecated a specialised matriculation examination. He would point out that other Faculties, in addition to engineering, were endeavouring to obtain specialised examinations.

This concluded the programme of the joint Conference of Sections I. and II., which then adjourned until the following day.

SECTION III.—WEDNESDAY.

Section III. opened at 10.30 in the theatre with Mr. Robert Elliott Cooper's address, which was as follows:—In opening this section of our Conference upon practical training, I do not propose to occupy your time for more than a few minutes. The object of this section is to discuss and endeavour to settle some of the difficult questions which present themselves to young men who seek to obtain such practical training as would fit them for the career of an engineer, apart from any particular branch of engineering, and also to enable them to obtain the recognition of the Institution of Civil Engineers, which is becoming more and more important.

In discussing these questions, it is obviously most important that, if possible, all should be agreed as to what "practical training" really means. I am afraid, however, that the general opinion upon this point is by no means settled. In the early days of engineering the practical training of a young engineer in the mechanical branch of his profession went very little beyond the performance of the work of a mechanic, under conditions that fell far short of what was necessary to train him so as to enable him to take a superior position in regard to the design or control and management of engineering works.

A great advance was made when it was recognised that it was essential that young engineers should possess a sound general education, and also some scientific knowledge bearing upon the theory and practice of their profession. Although such an education has generally shortened the period of practical training, it has by no means taken the place of such training, or rendered it less necessary to all who hope to succeed in their profession. The first point which I should like to make clear is that real and useful practical training, whether in design, construction, or management of works, can only be obtained under the actual or commercial conditions which necessarily cannot be found in educational establishments. There is an idea in the minds of a good many people that the old custom of pupilage had passed away. That, however, is very far from the case, and in my opinion, the routine (under proper supervision) of the drawing-office and works, whether in the civil or mechanical branch, is just as important now as it was considered in former days, the only difference being that the young engineer of to-day is better equipped, by reason of the advance in scientific education, to take advantage of the practical training afforded him. Dealing for a moment with "Civil" engineering (as distinct from mechanical engineering) it is obvious that any efficient training must embrace experience in various kinds of work, such as designing, drawing, specifying and estimating, all of which would be part of the ordinary routine of an engineer's office. He must also be trained in construction work, embracing setting-out, measuring up, and general administration. A great mistake which many young engineers make is in thinking that all that is necessary on completion of their college career to make them efficient assistant engineers, is either to go into a workshop and spend, say two years, on the ordinary work of a mechanic, or—if "civil" engineering is to be his career—to go to a contractor upon some works of construction. The knowledge so gained is most useful, but without the office training, embracing the subjects, amongst others, which I have mentioned, he is only half equipped for the work of his profession. There is doubtless a belief in some quarters that the system of training by definite apprenticeship and pupilage, which was certainly affected and modified some years ago by reason of the movement in favour of better scientific education, has fallen largely into disuse, and statements are sometimes made that it has been actually abandoned by the majority of engineers. Such an idea can only arise from an imperfect or very partial acquaintance with the engineering profession. It may be quite true that in a few branches of engineering, or pursuits cognate with engineering, pupilage, or its equivalent, does not occupy its former place, but taking the profession as a whole, that is not so. In corroboration of this statement may be quoted the result of an inquiry made on behalf of the Council some months ago, which was directed to ascertain the position of pupilage, or other equivalent practical training, in manufacturing workshops, and in the engineering departments of important railways, docks, and other large undertakings and authorities. The result of that inquiry was that in 75 per cent. of the cases considered there were regular arrangements for pupilage, and in only 25 per cent. was no provision made for such regular practical training. It may be observed that of the 25 per cent. more than half the cases occurred in the engineering departments of municipal authorities, which certainly might be expected to make better provision for the acquisition of practical training of a kind suited to prepare young men to become competent municipal engineers. The inquiry referred to was not addressed to engineers in private practice, but it is a matter of common knowledge that the system of pupilage remains extensively recognised amongst consulting engineers, although the requisite term of such training has been shortened in view of the better educational qualifications now generally possessed by young engineers. The question of the conditions under which practical training can be, or should be, obtained, and of the means which might be taken to procure for intending young engineers, whether college-trained or not, fuller and better opportunities of acquiring that practical knowledge of engineering as actually performed which is essential to their becoming good assistants and, later on, efficient masters, is a matter for discussion and consideration by this section of the Conference, from which it is trusted that good results and a better understanding may ensue. It is, I think, highly desirable that we should, at the outset, be reasonably clear as to what practical engineering training really means and involves, especially from the point of view of enabling a young engineer to show the possession of those qualifications which are recognised by the Institution of Civil Engineers in regard to its corporate membership.

This was followed by the reading of the two following short papers, which were discussed together.

THE APPORTIONMENT OF TRAINING BETWEEN PRACTICAL WORK AND SCIENTIFIC STUDY, WITH SOME SUGGESTIONS APPLYING TO APPRENTICES IN OR ON WORKS FAR DISTANT FROM THEIR HOMES.

By ALFRED FERNANDEZ YARROW, M. Inst. C.E., and members of his staff.

The observations now submitted deal only with two points:—(1) Although the advantages and disadvantages from a purely educational point of view of what is termed the "sandwich system" have been frequently dealt with, the social aspect of the question has perhaps been overlooked, and this is one point with which we propose to deal. In considering the question of engineering students, we have been frequently impressed by their need of being accommodated with courses of study which would enable them to get their practical training without the necessity of being banished from home influences for a continuous period of several years at a most critical time in their lives. It will be admitted, for instance, that London can no longer be looked upon as an engineering centre; consequently, it is necessary for young men to obtain their practical training in the North, where engineering workshops exist. This practical training, if continuous, would probably not be of less duration than three years, and these young men, who possibly have no friends or relations with whom they can live when serving their apprenticeship away from their family, must reside in lodgings under conditions of much discomfort, and if this condition should exist for lengthened periods during the student's youth, at an age when every young man is subject to a certain amount of temptation, experience has shown that the risk is considerable. Now, if their practical and theoretical training can be so arranged that during the six summer months they work in the shops while living in lodgings, and during the six winter months they take up theoretical study in the colleges, living at home and subject to good influences and affectionate surroundings, this home influence is a source of great security, especially if the six months they work in the shops be during the summer, when their spare time can be spent in outdoor pursuits.

Unless courses of study can be arranged to alternate with periods of practical work, so that the young man avoids being banished from his home, he will clearly be placed at a disadvantage compared with those young men whose homes are in the manufacturing districts, such as Glasgow, Newcastle, or Birmingham. For these reasons we submit that the colleges, especially those in London, should endeavour to arrange their courses of study so as to conform to the social conditions indicated above as desirable, and that they should arrange their engineering courses of study during the winter months.

We are aware that many firms object to take young men into their works for such short periods as six months, but we believe this system will be advantageous in the distant future to the engineering industry of the country, and those firms who have at heart the future success of their establishments should, at some small present inconvenience, be prepared to fall in line for the general benefit of the engineering industry, of which their firm forms a unit. Also, it must not be forgotten that in treating their apprentices with special consideration, firms may possibly be cultivating an advantageous connection for the future, for many apprentices attain positions of responsibility and have the means of placing orders with the firms where they learnt their profession. We have for years allowed students during their summer vacation to work in our shops, and we are prepared to continue this practice conditionally on their being with us a total period of not less than 36 months, which together with four winter sessions at college of six months each, would represent a total period of training of five years.

Professor Dalby, to whom we sent a copy of these observations, wrote:—"Whatever may be the difficulties in the application of the system, I feel sure that if it were possible to obtain universally a six months' session, alternating with six months' practical work in the summer, a condition of things would be arrived at which would be beneficial both to the college and to the students."

(2) We would draw attention to the desirability that in works some member of the staff should be looked upon as an adviser to the apprentices, it being among his duties to get into personal touch with each young man. The young men should not be thrown into the shops without anyone to advise them in their studies or otherwise, or to whom they could turn in a difficulty. It is clearly undesirable for an apprentice to be simply under the eye of the foreman, who would probably not trouble himself about the interests of the lads themselves. Those who have worked in the shops will know that it is almost impossible for a young man to obtain an interview with the heads of the firm, even if he had the courage to do so; he has to pass through the various offices, and will probably be stopped somewhere on his way, and even if he did get access to the heads, they would doubtless be engaged on important matters, and would have very scant time to devote to the lad.

It would therefore be a very desirable thing if in works some gentleman could make it part of his business, as it were, to befriend the apprentices. He should be accessible at all times, and should make a point of interviewing each lad at least once in three months, and ascertain if he could be of service to him. He should also from time to time ascertain what progress is being made by those lads who attend evening classes by periodical visits to the local technical schools. A record should be kept in a book for the purpose, so that the heads of the firm can see at a glance the opinion formed of the various apprentices. This system would not only be a great advantage to the lads themselves, but would enable employers to recognise ability and industry, and select wisely those young men whose services they might desire to retain when their apprenticeship terminates, for it is a notorious fact that often employers have lost the services of many capable men through being ignorant of the talent that has passed through their works. Consequently, we submit that, taking a broad view of the two questions under consideration, employers would probably be gainers by facilitating what is herein indicated as desirable.

THE REQUIREMENTS OF PRACTICAL TRAINING IN WORKS, WITH THE NECESSARY COMPLEMENT OF SCIENTIFIC STUDY.

By WILLIAM HENRY ALLEN, M. Inst. C.E.

During recent years we have seen a great change in ideas as to the value of engineering apprenticeship. The obvious cause of this change is the now generally recognised principle that the period of apprenticeship must be combined with a period of college training, either before or after apprenticeship. The original idea of a seven years' apprenticeship in a workshop only lapsed in the 'sixties. Since that time a period of five years has been considered as usually desirable, but now that it has become necessary for a young man to devote a considerable period, in addition to his apprenticeship, to scientific study at college or the university, it has been found necessary to curtail the period of works' apprenticeship.

I think it is now fairly certain that no man can expect in future to take a good position in life as an engineer without having equipped himself for his work by taking advantage of the best that our age can offer in the way of scientific training and opportunities for scientific study, as well as by a period of apprenticeship in practical engineering under commercial conditions. If he has not done so he will find it exceedingly difficult to compete with the man who has thus availed himself, and who has gained a clearer insight into those principles which form part of his work, and also developed those faculties of clear thinking and accurate reasoning which are so invaluable to an engineer.

In spite of this very important development one must not disparage the value of the workshop apprenticeship, as it is so often the lot of the engineer to have to deal with quantities of which we have, as yet, very little accurate knowledge. Problems of this nature are of almost daily occurrence in practical work; hence experience of them at the present state of knowledge must be gained by personal contact with them. In this connection it should be remarked that much of the value of scientific training and study for the engineer is more of an indirect nature than the mere acquisition of certain mental tools and equipment, and consists very largely in the value of such studies as a means to mental development, so as to enable the engineer to face any difficulty with an open mind, whose power of insight has been sharpened, and which has been trained in methods of accurate reasoning and logical deduction.

One is often asked, in the case of a student determining to go both to college and to works, which he should enter first. My views on this point are that a schoolboy coming direct to the works does not succeed so well or stand the same chance as the one who has been to college first. The latter has been better broken in, as it were. He has been formed in character by association with others of the same age in like pursuits, has learnt the value of time, and to recognise the serious side of life, and those qualities which tend to manliness, and has also received training in mental development. Much economy in time is also effected by preserving the continuity of study. I should therefore say that the man who sets himself the task of obtaining his degree before entering the works stands a much better chance of securing a higher and more responsible position in life than the one who is trained in the reverse order. The former not only takes a greater and more complete interest in the works and workshop life, but makes the most of his time, and grasps ideas and their principles much more readily than the man who comes to the works with merely a public school training.

Another question frequently asked is, "How much study should a pupil undertake during the period of his practical training?" In my opinion, if a young man conscientiously does his duty from 6 o'clock in the morning until 6 in the evening, he will find that as much as his health can stand, without burdening it by further serious study at night. At the same time, unless some attention is paid to the work which has been done at college, this part of his studies is apt to lose its freshness and interest for him, his attention being concentrated purely on his daily task to the exclusion of everything else. My custom has been not to make this a compulsory part of the training, but to give lectures weekly explanatory of the actual work being carried on in the shops, thus greatly increasing interest in and adding to the knowledge of the work being done.

It must be remembered that the workshop to-day, involving as it does so many different classes of measurement, the use of instruments, and more elaborate styles of drawing—all necessitating a much higher educational standard throughout the works—requires a man of more thoughtful age and education to enter fully into his workshop apprenticeship than was formerly the case. A college training, moreover, must inculcate that habit of accuracy of thought which cannot be obtained in any other way.

As regards the requirements of workshop training, there seems little doubt that a period of three years—the actual time depending on the previous education of the subject—comprising a year in the drawing-office, should be spent in the works in a not too specialised manner, that is to say, it should cover work in some or all of the branches of mechanical and electrical practice, which may be found in some of our better establishments. So long as this part of an engineer's training has to be carried out under commercial conditions, so long will it be more or less dependent on the state of trade and other local conditions. This is not altogether a disadvantage, for the alternating periods of exceptional activity in trade, and the reverse, will carry their own important lessons to the observant student.

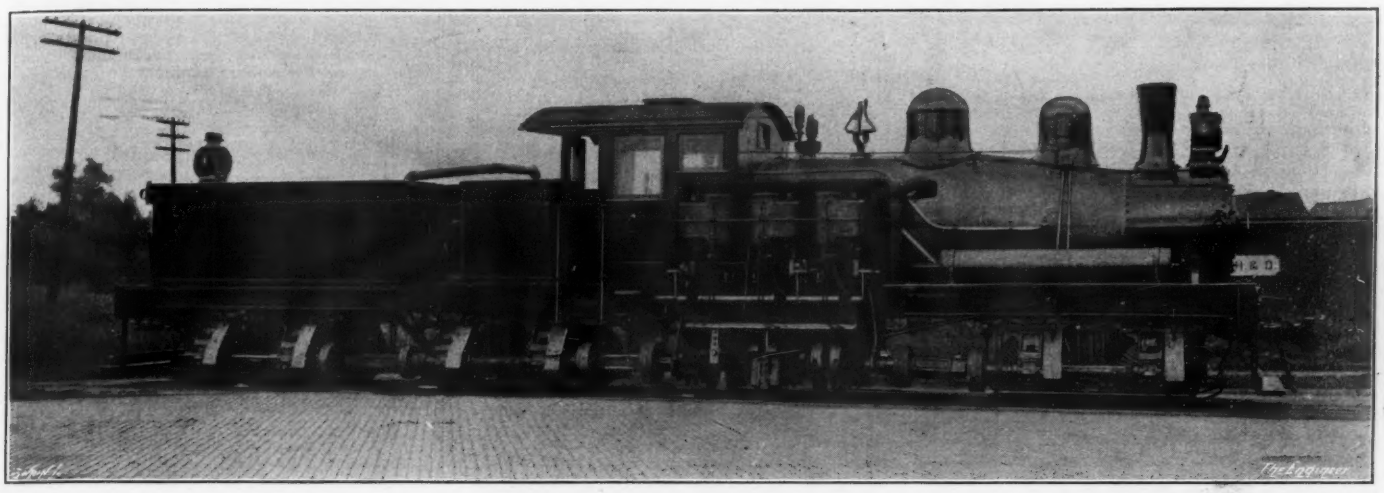
It will always be difficult, if not impossible, to lay down a plan either for scientific study or works' apprenticeship which will suit all, and each individual case will require consideration on its merits; at any rate, whatever plan is arrived at will have to be very elastic as regards the arrangement of details. I think we are inclined at present to attach rather too much importance to the direct value of scientific study as being the means of providing the student with certain mental tools for use in after life, and too little to the indirect side to which I have already referred, *i.e.*, the development of the mental faculties generally, and the cultivation of a true scientific insight.

Without a systematic training, sole reliance must be placed either on continued experiment or on a highly developed instinct of discernment, in order to diagnose what must then be invariably regarded as phenomena.

Mr. F. E. Robertson, opening the discussion, referred to the total want of education in one branch of their profession—locomotive engineering. His firm were consulting engineers for several Indian railways, and part of their duties was to advise on the selection of candidates for technical departments. A very large number of candidates of all kinds passed through their hands in the course of a year, from firemen to the chief engineers. Their experience was that whilst in other branches of the profession there was no difficulty in getting any number of candidates

SHAY GEARED LOCOMOTIVE

THE LIMA LOCOMOTIVE AND MACHINE COMPANY, LIMA, OHIO, ENGINEERS



well qualified both in theory and in practice, they could not put the number of qualified locomotive engineering candidates higher than about 5 per cent. They did not set their demands too high, but it was found that the vast majority of candidates had no knowledge of mechanics, and did not pretend to have it; nor was their practical knowledge in the shops so far as materials were concerned any better. There surely must be a remedy for such a state of affairs. It was not reasonable to suppose that the input into the locomotive branch was worse than the input into other branches of the engineering profession; but the output was truly deplorable. Amongst their rejected candidates were quite a number of men occupying similar positions to those sought on British roads. If superintendents would refuse to put in charge of sheds, and would not recommend as efficient for other jobs, men who had no knowledge of engineering, he thought they would soon remedy this reproach to their branch of the profession.

Professor J. O. Arnold said he had listened to the last speech with a considerable amount of astonishment. He could say from his personal knowledge of the Midland Railway and the locomotive shops in which his own son was a privileged apprentice that no such dismal condition prevailed as that which had been so luridly sketched by Mr. Robertson. The Midland Railway Company had already adopted the very excellent suggestion made by Mr. Yarrow that somebody should be responsible for looking after the well-being of their privileged apprentices, and they had appointed a very able scientific man who was formerly at the Manchester University, who was solely responsible for watching the education, and perhaps quietly watching the private lives of their privileged apprentices, and any lapse of the kind indicated by Mr. Yarrow was quickly dealt with. Mr. Henry Fowler, the chief mechanical engineer, gave his privileged apprentices two mornings a week to attend the Birmingham Technical College. The examinations were very severe, and, in addition to that, there was an annual examination held by the Midland Railway of every pupil and every privileged apprentice in their employment, so that speaking from his personal knowledge, at any rate of the Midland Railway Company, they were taking every possible step to produce the kind of man Mr. Robertson had asked for. There was, however, a lamentable lack of correlation of knowledge between the engineer and the metallurgist. Metallurgists had been engaged in research, and many of their researches had thrown considerable doubt upon the accepted theories of the strength of materials. The Midland Railway authorities had adopted a scheme which had been in operation for two years, that in their fifth year their pupils should be sent to the metallurgical department of the University College one day a week for one year.

Mr. E. R. Dolby said that, in his practice as consulting engineer, he was chiefly occupied with engineering works in connection with large buildings, which brought him into close contact with a number of architects, some of whom were very eminent men. He had put himself to some trouble to inquire from them as to their course of training, but he had never succeeded in finding one architect who had been through what he might perhaps term a practical course of training; that was to say, one who had worked as a carpenter, bricklayer, or mason, or one who had attempted to maintain any manual dexterity in even one handicraft. The architectural profession was of considerably older standing than engineering, and in the course of its long evolution it had arrived at this stage that building works were usually carried out under four personalities, the architect, the quantity surveyor, the builder, and the clerk of the works. Of those four personalities, therefore, there were two who had had training in what he might call manual dexterity. If such a sub-division were necessary in the profession of an architect, it seemed to him that to lay down such a course of education as was now proposed was comparable to an attempt in the architectural profession to prepare one person to fill four posts. He suggested that the course of engineering education should be so mapped out as to suit the four different species of members which were represented in the engineering profession just as they were in the architectural profession.

Mr. C. O. Burge believed there was an insufficient preparation for the work of a civil engineer abroad. In nearly all the papers that had been printed and circulated there was hardly a reference to the requirements of the civil engineer abroad. He thought it would be a very good thing if the professors of the various academical institutions would either from their own knowledge, which would be best, or from assistance, give the students some training in the different conditions which they were likely to meet when they went abroad.

Mr. E. Benedict thought that the case of the Midland Railway Company must be exceptional. It certainly was a very magnificent example of what ought to be done, but he went a little further, and thought that in a place like that, where there were a great number of premium apprentices, there ought to be a hostel, or some place such as there were in colleges, where the young men could live under a tutor with a dame, and so on, more or less reminding them of home conditions. To teach them as he was taught, and to leave them to live in lodgings amongst a lot of young men, without any help or guide from the man who was taking their money, or their father's money, was not right. He thought people who accepted premiums from a number of pupils should consider they had a certain amount of responsibility.

Mr. A. H. McCallum, speaking as a young man on behalf of the younger men, said the sandwich system introduced by Mr. Yarrow appeared to be more desirable when considered on paper than in actual practice. There were difficulties in practice, and there was the grave objection that the continuity of theoretical study was very definitely broken up. That was as grave an objection in six months' periods as in longer periods. The tendency was, it seemed to him, to mix the two classes of training more intimately. He thought that during the time of five or six periods it was eminently possible successfully to combine the two systems, to have a man looking after the pupils, and to train them both in theory and practice at the same time.

Mr. J. M. Moncrieff saw no relation between the profession of an architect and that of an engineer; the profession of an architect covered a much wider ground; he thought they could not miss out the practical work of the civil engineer. He noted that in the chairman's remarks a civil engineer was differentiated from a mechanical engineer, but he held very strongly that every civil engineer ought to have mechanical engineering education.

Professor E. G. Coker said the two papers by Mr. Yarrow and Mr. Allen raised very important questions, particularly to those who were engaged in teaching. It was a very remarkable thing that the gradual removal of most of the large engineering works to the north had deprived students in London of most valuable object lessons, because they did not now see in their immediate neighbourhood great engineering works being carried on, and they were apt to get a false impression of what engineering was. He was therefore very glad indeed to note the suggestion made, both by Mr. Allen and Mr. Yarrow, and he hoped it would lead to a very much more intimate connection with works for the London student than had up to now been the case. He favoured the sandwich system because he found students coming in from schools had no real idea of what engineering was. They could not get in college any idea of the way engineering works were carried out on a commercial scale, and they were apt to get an erroneous impression of what was important and what was not important, and it was only after they had been in works that they realised what the training had been directed to. Six months' training in works and six months in college was a most valuable system.

Mr. A. H. Preece said that the real question was practical training. The tendency of the school training was to teach the student how to absorb knowledge; the tendency of the college training was to teach him how to appreciate knowledge; and the training he had got in a workshop to teach him how to apply his knowledge. The question really was whether the student was fitted when he left his public school to appreciate the knowledge that was put before him. Many a youth was totally unfitted to be let loose in a workshop, but possibly after he had been three years in college he would be able to take advantage of his opportunity. He had noticed that in American practice some colleges devoted the first year of the student to teaching him practical matters and not theoretical matters, and the professor said they did that in order to force the student to see what he should know. He thought in a great many college courses the student in the first year was worried and troubled with theoretical matters, and was never given any indication as to the direction in which those matters were going to have a practical bearing. There was also a tendency on the part of the colleges to try and teach the students practical work in their own laboratories. Most of them there would agree with him that laboratory workshops in colleges necessarily were mainly for the purpose of keeping the professors up to the mark.

Professor W. E. Dalby said one of the main features of Mr. Yarrow's paper was the application of the sandwich system of six months in college and six months in the shop, which carried with it so many advantages. He believed all the colleges would welcome such a system, but the difficulty was on the other side—the employers. The main point to consider was how the system could be carried out, and whether the works would open the door more to the college students to allow them to work during their vacations or during the six months. He had been in communication with a large number of firms with the object of obtaining openings for students in this way, and in a great many cases the response had been very gratifying; but the difficulty they had had was the pupil finding after he had left the works and received his training, even if the sandwich system were adopted, of having to pay 100 guineas a year in order to get again into the works. There should be more correlation, and he would like to see the college itself looked on as an extension of the works. The pupil should be attached to the works, and the college should be an extension of them. He agreed that the general object of the scientific training of a locomotive engineer was not to be compared with the general object of the other branches of the profession, and they had tried to remedy that at the Imperial College.

There then followed the reading of two papers, one by Sir Hay Frederick Donaldson and the other by Mr. W. B. Worthington, which, with the discussion on them, we are obliged from lack of space to hold over till our next issue. The reading and discussion of these papers concluded the Wednesday sitting of the Conference.

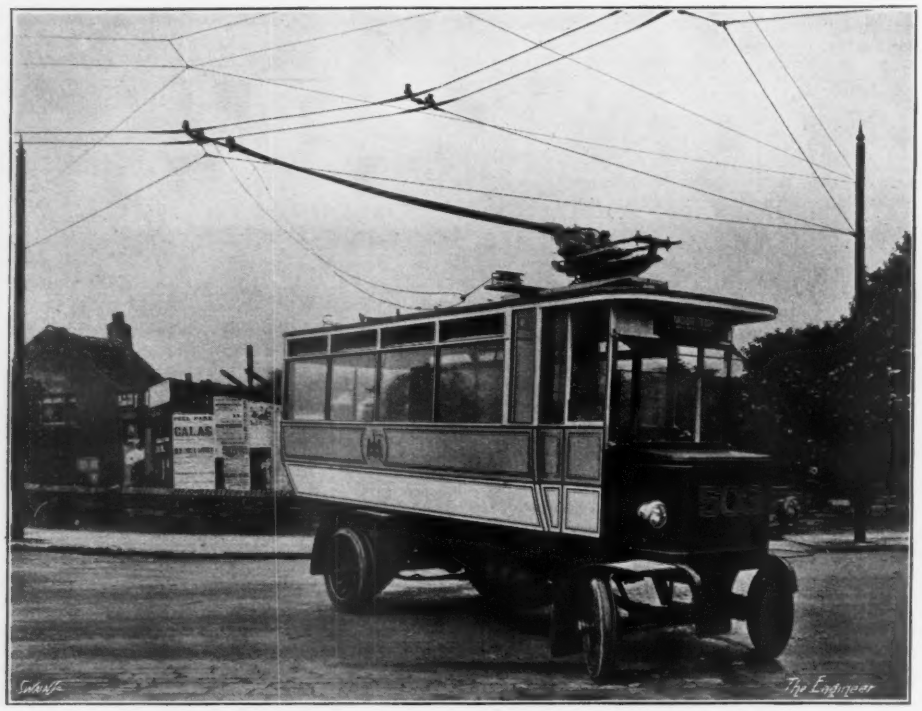
GEARED LOCOMOTIVES FOR NEW SOUTH WALES.

IN THE ENGINEER of April 14th there was given a description of the Wolgan Valley Railway, in New South Wales, and of the different types of locomotives which were considered for working this line, which includes a long incline of 1 in 25—equivalent to 1 in 22½ in view of the sharp curves. The Shay geared locomotive was adopted, and three 70-ton engines and one 90-ton engine were purchased. We illustrate herewith a 90-ton Shay locomotive, which is practically identical with that sent to Australia. It has a bogie under each end, and all the wheels on one side—including those of the four-wheeled tender—are driven by pinions on longitudinal shafts gearing with bevel gears on the faces of the wheels. Flexible connections are provided in the shafts to allow for the curving and the vertical movements of the bogies. The cylinders and driving gear are on one side only.

These locomotives were built by the Lima Locomotive and Machine Company, of Lima, Ohio, which builds Shay engines of various sizes. They are used on forest and mining railways, and also on steep gradient branch lines. Other types of geared engines are used also, but most of these are confined to the smaller sizes for light and rough railway lines in forests, or to mines. The principal dimensions of the 90-ton Shay engine for the Wolgan Valley Railway are as follows:—

Cylinders, 3 vertical, inverted	14¼in. × 15in.
Wheels, diameter	36in.
Wheel base, rigid	4ft. 8in.
Wheel base, engine and tender	43ft. 3½in.
Boiler, diameter	4ft. 10½in.
Steam pressure	200 lb.
Fire-box, radial stays, sloping crown	7ft. × 4ft. 10½in.
Tubes, No. 246, diameter	2in.
Tubes, length	11ft.
Heating surface, total	1536 sq. ft.
Grate area	34 sq. ft.
Ratio of heating surface to grate area	45 to 1
,, ,, cylinder volume	355 to 1
Ratio of grate area to cylinder volume	7.9 to 1
Coal capacity	5½ tons
Water capacity	3500 gallons
Weight in working order, average	90 tons
Tractive power	40,400 lb.

RAIL-LESS TROLLEY CAR FOR LEEDS



TRACKLESS TRAMWAYS.

ON Tuesday, June 20th, the electric tramway systems of Leeds and Bradford were officially extended by the adoption of sections laid on the rail-less trolley system. These sections are the first track-less routes to be worked in this country, and are the outcome of a visit to the Continent some two years ago on the part of the Leeds Tramway Committee and the general manager, Mr. J. B. Hamilton. Parliamentary powers were obtained last year for the present Leeds route from the City Square to Farnley, a distance of about 4½ miles. From the City Square for nearly a mile the vehicles pass along a road in which the electric tramways are already in operation, and by an adaptation of the overhead equipment, the rail-less vehicles are enabled to utilise the same positive wires as the other trams. Elsewhere the overhead equipment comprises ordinary cast iron poles and four 0000 S.W.G. grooved hard-drawn copper trolley wires each 0.126 square inch cross-sectional area. These are carried on bracket arms 18ft. long, the two inside wires being positive, and the two outside wires negative. The direct electric current is supplied by the power station at Crown Point, and the pressure at the trolley wires is 525 volts. Section boxes and section insulators are provided at distances apart of ½ mile as in tramway practice, but the negative wires are continuous from end to end, being cross-connected at distances not exceeding a ½ mile to minimise losses, and for the same reason these wires will be bonded to the existing tramway rails near the old terminus at Whitehall-road. The feeders for the rail-less overhead system are connected to positive and negative boosters at the power station for boosting when necessary.

The illustrations given above and below on this page represent the vehicle adopted. It has seating capacity for twenty-eight persons, and as the passenger entrance and exit is at the front the driver of the vehicle can also act as conductor. The vestibule on the driver's platform has adjustable side windows and hinged wing screen and protection is provided for luggage. The chassis is designed on orthodox motor car lines, and has artillery wheels with solid rubber tires, twin on the drivers and single on the steering wheels; and the wheel base is 13ft. There are two brake systems, one on the countershaft, operated by a foot-pedal, and the other consisting of drum brakes on the rear wheels, operated either by hand lever or pedal, with a ratchet device to hold the brakes on. It is driven by two 20 brake horse-power electric motors, which, when running at 1000 revolutions per minute, give a travelling speed of 10 miles per hour. The motors are of the Siemens pattern, series wound, with shunt fields provided with commutating poles. The controller is of the Siemens series parallel magnetic blow-out type, with an arrangement for cutting out either motor as desired, but no provision for rheostatic braking. The main barrel has nine positions and the reversing barrel six positions. Each motor drives one wheel through double reduction worm and chain gearing, the chains being protected from dirt and dust, but being easy of access when necessary for adjustment.

The trolley is of the double under-running type, and will allow the vehicle to travel at a distance of 15ft. from the centre of the trolley wires, measured from the centre line of the vehicle. It is arranged so that the negative trolley may be put out of action, and thus allow the car to run with the positive trolley only on the line. Where no overhead negative wires are provided, such as in and about the depôt, a rail collector is necessary. This consists of a skate, hinged at the rear end of the vehicle, and provided with means for raising and lowering, so that when the negative trolley is out of action the electrical circuit will be completed through the ordinary rails. This arrangement permits of a deviation of the vehicle of 5ft. The work has been carried out under the supervision of Mr. J. B. Hamilton, general manager of the Leeds tramways, by the Railless Electric Traction Company, Limited, Moorgate-street, London, E.C. The bodies of the vehicles are by Hurst, Nelson and Co., Limited, the chassis by Alldays and Onions, and the electric motors by Siemens.

CHASSIS OF THE RAIL-LESS TROLLEY CAR

INTERNATIONAL ELECTROTECHNICAL COMMISSION.

IN conformity with the wishes of the Brussels Conference, held in August, 1910, the delegates of the British, French, and German Electrotechnical Committees met at Cologne in the middle of May last. Professor Eric Gerard, having presided at the Brussels Conference, at which the subject of nomenclature had been much discussed, was specially invited to attend, so that not only was there a continuity of ideas, but the delegates were entirely free to put forward their particular views. Those present were: Professor Eric Gerard, president of the Belgian Committee; Mr. E. Brunswick, delegate of the French Committee; Dr. E. Budde, president of the German Committee; Dr. Silvanus Thompson, delegate of the British Committee; and Mr. C. le Maistre, general secretary of the Commission.

Before the actual work of the meeting was commenced, suggestion was outlined by Dr. Budde dealing with the international unification of symbols. On behalf of the German-speaking nations, as represented by the Elektrotechnischer Verein, of Berlin, Dr. Budde said that they would be prepared to abandon the use of "W" for resistance and adopt "R," if the English-speaking nations, on the other hand, would adopt "I" instead of "C" for current. Dr. Budde was quite ready to exclude "J" as synonym for "I," owing to the confusion which would arise due to the fact that "J" is already employed to represent other quantities. Dr Thompson, on behalf of the British Committee, willingly concurred in this suggestion, and as the American Institute already employs "I," and through the good offices of the American Electrotechnical Committee the National Electric Light Association of America is being approached in the matter, there is every hope that at Turin the symbols "I," "E," "R," will be universally adopted.

The discussion of the work of the various Committees on the German list of terms put forward at Brussels was then entered upon, and a list of some 50 industrial terms and definitions was agreed to in French and English. The word "industrial" has been introduced so as to distinguish this work from that of the vocabularies in course of preparation by several of the Committees. The reason being that the vocabularies include definitions of a character more abstract and general, and more rigidly scientific, than is necessary in the case of industrial terms, which are more conventional, and can therefore be defined in less academic language, and yet prove of inestimable value to the industry by facilitating commercial transactions between buyer and seller. As the time at their disposal was so limited, the delegates intend to meet again at Turin early in September so as to have an opportunity of revising their work prior to submitting it to the plenary meeting. In the meantime the work already carried out is being issued to the various Committees for their consideration.

Special mention must be made of the work of the Danish Committee, which was presented in such an admirable manner, and has been of very considerable assistance to the Committees generally. The work of the Japanese, the Mexican, and the Spanish Committees was also most complete. The small Committee has been so successful in its task that in all probability the appointment of other small international Committees, to study certain particular subjects in a preparatory manner, will be considered in the near future, and thus work will be going on continuously, and subsequently more rapid progress ensured.

NEW DANISH TORPEDO BOAT.—The torpedo boat Soridderen, built for the Royal Danish Government by Yarrow and Co., Glasgow, ran her official full-speed trial on Saturday last, June 24th, on the Skelmorlie deep-water measured mile at the mouth of the Clyde. The contract speed of 27 knots was easily attained during a three hours' continuous trial, with the vessel carrying a load of 50 tons. The trial was under the supervision of Sub-director Adolph and Commander Wenck, representing the Danish navy. The Soridderen is 181ft. 9in. long by 18ft. beam, and is propelled by twin screws driven by turbines of the Brown-Curtis type, constructed by Messrs. Yarrow. Steam is supplied by two Yarrow water-tube boilers of the latest type.

ROYAL SOCIETY OF ARTS.—The Council of the Royal Society of Arts have awarded silver medals for papers read during the past session as follows:—At the ordinary meetings: Mr. Campbell P. Ogilvie, "Argentina;" Dr. Vaughan Cornish, "The Panama Canal;" Mr. Reginald A. Smith, "Roman London;" Mr. Philip Joseph Hartog, "Examinations;" Mr. George A. Stephen, "Bookbinding;" Dr. Leonard Hill, F.R.S., "Caisson Sickness and Compressed Air;" Dr. James Cantlie, "Plague;" Mr. George B. Heming, "Art Education in Jewellery, &c.;" Professor Raoul Pictet, "Les Basses Températures:" Mr. Frank M. Andrews, "Architecture in America." In the Indian Section: Mr. Robert Fellowes Chisholm, F.R.I.B.A., F.S.A., "The Taj Mahal;" Mr. Reginald Murray, "Banking in India;" Mr. Claude Hamilton Archer Hill, 'Education in India;" Sir Thomas Henry Holland, K.C.I.E., F.R.S., "Mineral Development in India;" Dr. W. R. H. Merk, "The North-West Frontier Province." In the Colonial Section: Mr. A. Montgomery, "Mining in Western Australia;" Mr. F. Douglas Osborne, "The Tin Resources of the Empire;" Captain R. Muirhead Collins, R.N., "The Commonwealth of Australia;" and Mr. F. Williams Taylor, "Canadian Banking."

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

LIVE STEAM FEED HEATING.

SIR,—I have read Mr. Hamilton's letter in your issue of June 2nd regarding low-pressure feed heaters, and I wish to say that he is quite mistaken in his remark that it is impossible to show any economy for such heaters on thermal grounds. I refer him to an article on "Feed-water Heaters" by Dr. A. C. Elliot in *Engineering* of January 11th, 1895, and also to the following, which is the accepted thermo-dynamic principle upon which the economy is based:—

The maximum efficiency of a heat engine is represented by the equation $\frac{T_1 - T_2}{T_1}$, where T_1 = initial temperature of the working fluid and T_2 is the temperature due to the back pressure against the piston. The efficiency of the steam engine cycle falls short of this, because the heat of the feed is not supplied at the maximum temperature (T_1), but along a gradually increasing temperature line. The work done falls short of the Carnot's cycle by the area ($a e h$)—Fig. 1. The Carnot's cycle may be approached on the

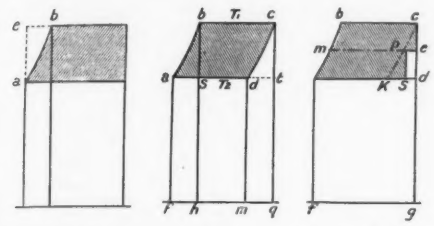


Fig. 1 Fig. 2 Fig. 3

regenerative principle of abstracting heat from the steam during its expansion from the high-pressure cylinder to the condenser for the purpose of heating the feed water. For example, as shown in Fig. 2, instead of expanding adiabatically from T_1 to T_2, sufficient heat is abstracted from the working fluid to the amount represented by area ($m d c g$) for feed heating purposes, and this amount being equal to that required to heat the 1 lb. of feed water to temperature T_1 from T_2, this heat will equal area ($f a b h$) = area ($m d c g$). The net heat added = area ($h b c g$), and the heat rejected to condenser = area ($f a d m$) = area ($h s t g$).

The efficiency of the cycle is therefore:

$$= \text{heat represented by Carnot's cycle}$$

$$= \frac{a b c d}{f a b c d m} = \frac{s b c t}{h b c g} = \frac{T_1 - T_2}{T_1}.$$

Mr. Weir has based his heater approximately upon this thermo-dynamic principle, but, instead of the steam expanding adiabatically from (c) to (d), he takes a portion of the steam from the receiver at (e)—Fig. 3—to heat the feed-water. The amount of dry steam present in the receiver is therefore reduced theoretically in the ratio $\frac{p e}{m e}$, and the expansion continues along a new adiabatic line ($p s$). The quantity $\frac{p e}{m e}$ of the steam in the receiver may be likened to an indefinite number of small increments of steam extracted during the expansion from T_1 to T_2, which expansion would approach nearer the curve ($c k$), and the efficiency would be equal to $\frac{T_1 - T_2}{T_1}$, which is the condition of maximum theoretical efficiency.

Thus, heating from the receiver of a triple engine is based upon sound principle, and economy results. To show this clearly, I will take a numerical example, the calculation being based upon a method by Professor Ripper, and shows clearly where the economy results—*e.g.*, compare the efficiency of a triple-expansion engine with and without feed-heating, the feed being heated in the former case by steam from the receiver between the intermediate and low-pressure cylinders. Conditions to operate:

Initial absolute temperature of steam, T_1	= 842 deg.
Temperature in exhaust pipe, T_2	= 624 deg.
Temperature in receiver R_2, T_3	= 740 deg.
Absolute temperature of air pump delivery	= 590 deg.

Suppose 10 per cent. of the steam is taken from the receiver R_2 at temperature T_3 to heat feed-water.

First, calculate efficiency without feed heating. Let (U) = units of heat converted into work when 1 lb. of dry steam expands adiabatically from T_1 to T_2 and exhaust at T_2, then total work done will be expressed by the equation

$$= L \frac{T_1 - T_2}{T_1} + (T_1 - T_2) - T_2 \log_e \frac{T_1}{T_2}.$$

L = latent heat = $(1437 - 0.7\,T_1)$.

Total work done in adiabatic expansion

$$= (1437 - 0.7\,T_1) \frac{T_1 - T_2}{T_1} + (T_1 - T_2) - T_2 \log_e \frac{T_1}{T_2}$$

$$= (847.6 \times 0.2589) + 218 - 187.2 = 250.24.$$

Now the total heat units supplied to 1 lb. of dry steam at T_1 = 842 deg. = H = $1437 + 0.3\,T_1$, reckoned from absolute zero 461 deg. below 0 deg. Fah., H = $(1437 + 0.3 \times 842)$, and from 590 deg. absolute we have $(1437 + 252.6) - 590 = 1099.6$ units.

The efficiency is therefore = $E = \frac{U}{H} = \frac{250.24}{1099.6} = 0.22819$.

To calculate the efficiency with feed heating—

Let U = the work done by 1 lb. of dry steam expanding adiabatically from T_1 to T_2.

Let U_a = the work done by 1 lb. of dry steam expanding adiabatically from T_1 to T_3.

Let U_t = total work done.

Let (n) = 1 lb. of steam, and since $\frac{1}{n}$ of the steam passing through engines is taken from the receiver at temperature T_3 to heat feed the total work done per lb. may be represented by the equation—

$$U_t = \frac{n-1}{n} U + \frac{1}{n} U_a.$$

As the value of (U) has already been found we must find U_a; by the same process as before, but expanding from T_1 to T_3 (U_a) work done by 1 lb. of steam expanding from T_1 to T_3 and exhausting at

$$T_3 = (1437 - 0.7\,T_1) \frac{T_1 - T_3}{T_1} + (T_1 - T_3) - T_3 \log_e \frac{T_1}{T_3} = 847.6 \times 0.12114 + 102 - 95.608 = 109.072 \text{ heat units.}$$

Let us now find the total work done (U_t). We have found the work done (U) by 1 lb of dry steam expanding adiabatically from T_1 to T_2 to be equal to 250.24 units, and we also know that 1 lb. of steam expanding from T_1 to T_3 is equal to 109.072 units. But as only nine-tenths of the steam expands from T_1 to T_2, and the other one-tenth from T_1 to T_3, we may express the total work done independently of that done in heating the feed water as U_t, and

U_t is equal to $\frac{n-1}{n} U + \frac{1}{n} U_a$

" " $0.9\,U + 0.1 \times 109.072$

" " $0.9 \times 250.24 + 10.9072$

" " 236.123 heat units.

Now the work done when no steam was withdrawn from the receiver was equal to 250.24, and thus is greater than when steam is drawn from the receiver, therefore before the efficiencies are comparative we have to find the net heat supplied in each case and for the case with feed heating we have to find (F_1), which is the temperature of the hot feed due to the missing quantity of steam $\frac{1}{n}$ from the receiver R_2.

Let F be temperature of unheated feed water.

Let F_1 be feed temperature after heating, and $1437 + 0.3\,T_1$ = the total heat of steam at absolute temperature T_1, and the equation becomes—

$$F_1 = F\left(\frac{n-1}{n}\right) + \frac{1437 + 0.3\,T_1 - Ua}{n} = (590 \times 0.9) + (1689.6 - 109.072) \times 0.1 = 689.05 \text{ temperature of heated feed.}$$

Note:—$F\left(\frac{n-1}{n}\right)$ = heat already in $\frac{9}{10}$ of feed.

$\frac{1437 + 0.3\,T_1 - Ua}{n}$ = heat in $\frac{1}{10}$ lb. of steam taken from receiver.

The net heat supplied with the hot feed from the receiver = $H_1 = 1437 + 0.3\,T_1 - F_1$.

This H_1 is the total heat required per pound of dry steam from feed temperature F_1 = 689.05 deg. absolute temperature.

$H_1 = 1437 + 0.3\,T_1 - 689.05 = 1000.55$ units.

The efficiencies can now be compared.

The efficiency without feed heating = 0.22819, as already found.

The efficiency with steam from receiver to heat feed

$$= E_1 = \frac{U_t}{H_1} = \frac{236.123}{1000.55} = 0.236.$$

This shows a thermal gain in favour of the feed heated system in the proportion of 0.236 : 0.22819, which is 3.4 per cent.

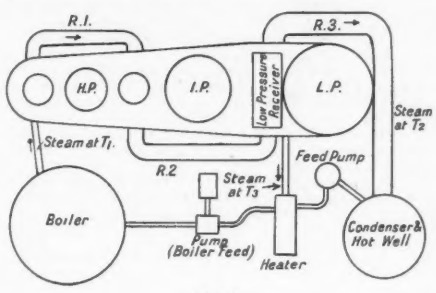


Fig. 4

The entropy diagram shows the economy clearly, and referring to diagram—Fig. 5—which shows graphically the conditions of the calculation. As per calculation the heat required per pound of steam when feed is drawn direct from condenser is given by area (h, a, c, d, f, h). When heat is supplied from steam taken from receiver to heat feed, the temperature of the feed has been raised, and the total heat required to generate 1 lb. of dry steam is less by an amount equal to the area (h, a, n, m, h) and the net heat required (m, n, c, d, f, m). This can only be accomplished by a loss of heat area (v, t, s, f, v) or the useful work = (r, t, s, e). From the foregoing calculation the gain is shown to be 3.4 per cent.

This thermal gain shown here theoretically is maintained in practice in a less degree, but the calculation is sufficient proof of

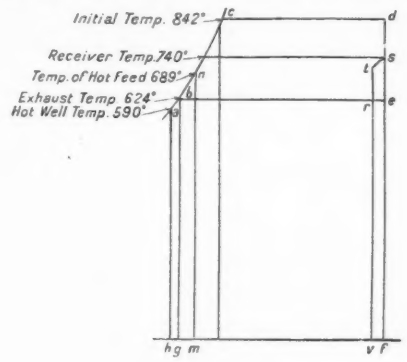


Fig. 5

the system of low-pressure feed heating being founded upon good thermo-dynamic principle, and the favour that this class of heater has found among marine engineers shows that, apart from the disadvantage that Mr. Hamilton mentions of connecting pipes and loss of efficiency, the Weir's heater is still in favour. Personally I think the fact of the heater being in the engine-room and always in view is in itself a recommendation, and fixed as it is on the suction side of the main boiler feed pumps—see Fig. 4—and supplied by low-pressure steam, combined with its simplicity and efficiency, make a combination that cannot be beaten by any type of live steam heater. I have read Mr. Hamilton's and Mr. Erith's remarks relating to the figures I gave for a Lancashire boiler test, and I wish to say that the point I desired to illustrate was that heating the feed to any great degree on the inlet side of the economiser was not good practice, because, due to the reduced efficiency of the economiser, the gain derived from the units of heat transmitted to the feed-water from the steam was not maintained on the boiler side of the economiser. I cannot understand in the case mentioned by Mr. Erith why the increase in temperature due to the steam heater was maintained on the boiler side of the economiser, which is contrary to all accepted theory relating to transmission of heat to fluids. With a higher temperature of entering feed the temperature difference between the fluid and the flue gases is reduced, and there is not the same rapid transmission of heat to the feed-water. What, then, was the improvement in Mr. Erith's case? Was there a higher flue temperature, or why was the efficiency of the economisers constant with a varying difference of temperature between flue gases and feed? In asking my reasons why the consumption of coal with a feed heater heating the water with exhaust steam was not reduced, I may say that due to the reduced efficiency of the economiser due to a less temperature difference between the flue gases and the feed entering the economisers, the heat transferred to the feed in passing through the economiser was less than for the case with no steam feed heat, with the result that the final temperature of the feed to the boilers was only a few degrees higher than the former case.

The rate of firing was therefore maintained fairly constant. I cannot account for the evaporation per pound of coal burnt in the steam feed heat test being lower than the other, but it must be remembered that the boilers were hand fired and the steam feed heat test for a longer period, when the boilers were no doubt beginning to be reduced in efficiency slightly. The low-pressure heater used was for a low temperature of feed and designed to heat the feed-water slightly to prevent scaling in the economisers. The engines exhausting to atmosphere through this heater proved to be very uneconomical, with the result that a higher temperature of feed resulted. The coal and water were very carefully registered, and I have no reason to doubt the temperatures taken. The whole matter rests in the economisers, and given a reasonable flue temperature and plenty of heating surface in the economiser, live steam feed-heating on the inlet side of an economiser to any high temperature is wrong; it is far better to just slightly raise the temperature to prevent scaling in the economisers which is already accomplished in condensing plants where the hot well temperature is anything in the region of 110 deg. Fah., and so get the benefit of an economiser to the greatest extent. Flue temperatures that are too high are uneconomical, but they are necessary where steam-heated feed of a high temperature is employed if any good is to be derived from the economiser. Better to leave the live steam heater out of the question where there are economisers, and the working of the plant as a whole would, in my opinion, be quite as efficient.

JAMES RICHARD FISH.

Bolton, June 16th.

TRAIN RESISTANCE.

SIR,—With reference to Mr. Dendy Marshall's article on this subject, he will find it quite impossible to obtain any information of real value from the few test results which are all that are ever published, and, as a matter of fact, the instruments in general use are not sufficiently accurate to allow of a satisfactory determination of the resistance.

The *crux* of the matter is the acceleration, positive or negative. A train hardly ever runs at an absolutely constant velocity for more than a few seconds, and so an acceleration correction is necessary. Unfortunately this is exceedingly difficult of determination; the old idea of a pendulum is absolutely useless, the difficulty, seldom properly appreciated, lying in the extreme degree of accuracy required, whilst the conditions on a locomotive moving at a high speed are very unfavourable, to put it mildly.

Consider the accuracy desired. Starting acceleration may amount to about 1½ft. per sec.², and acceleration on the road usually varies between + 0.2ft. and − 0.2ft. per sec.², being generally well inside these limits. Now an acceleration of 0.1ft. per sec.² means $\frac{0.1 \times 2240}{32.2} = 6.95$ lb. per ton, and adding about 9 per cent. to this, as a fair average allowance for the rotary inertia of the wheels, we have 7.6 lb. per ton as the acceleration resistance for 0.1ft. per sec.²

As we are dealing with total resistances of from 10 lb. to 40 lb. per ton as a rule, it is evidently necessary to read to one-tenth of this at least for accuracy even to the nearest pound; that is, we must read to the one-hundredth of a foot per sec per sec. at least. A pendulum 9ft. long would be direct reading, and it will at once be appreciated that an accuracy of $\frac{1}{10}$ft. on a 32.2ft. pendulum, or an angle of about one minute, cannot possibly be obtained on a locomotive or coach jumping about at high speeds, and with the inclination altered by the tractive force.

I have found the only possible way to be to use a very accurate speed, or, rather, time-distance recorder. With a paper running about 2ft. per mile, and a clock marking ¼ or ½ seconds, fairly accurate results can be obtained on the average, but even then isolated results have but little value. Last year my assistants and myself took over 600 indicator diagrams on an engine whilst working express passenger trains; for each of these I took the speeds from such a tape as that mentioned for three consecutive periods of two seconds, and more where there was irregularity, using the laws of "finite differences" for the final determination of the acceleration. Even so, the separate resistance determinations varied considerably, but the average plotted out to within 8 per cent.—generally much nearer—of a regular curve with a simple equation for speeds from 10 to 70 miles per hour. I do not see my way to give the figures, and Mr. Dendy Marshall must not expect to find such information in print in ordinary circumstances, but the facts may serve to show that what is very difficult, even under comparatively favourable conditions, with all the original records, cannot be done at all with just a few results. After studying over 2000 diagrams taken on the road, I have still merely put the tabulated information on one side to await further confirmation.

I do not care for Clark's formula, and much prefer one of the the form

$$R = a + \frac{b}{V + a} + \frac{V^2}{c},$$

a combination of a rectangular hyperbola with the usual parabola. The starting resistance is much higher than that when running at low and medium speeds. Such an equation allows for this, and it is sometimes necessary to consider speeds under 15 miles per hour, below which the parabola alone is of small value. The starting resistance I determine by putting one crank on a dead centre and gauging the pressure in the other cylinder, with a very small steam admission, so as to reduce the acceleration to the smallest possible, and in this way I have got concordant results from different engines.

There is far too much in print on the subject of train resistance, mostly based on insufficient and sometimes inaccurate data. Figures which have been "straightened up" for publication are often of small value, and deductions from such are generally worthless from a practical point of view.

Birkenhead, June 19th. P. H. PARR.

SCIENCE TEACHING AS A PROFESSION.

SIR,—The Institution of Civil Engineers will during the next few days hold a conference to discuss the question of the training of young engineers. May I be allowed a little of your space to touch on a matter of vital importance in connection with this subject that most probably will be overlooked at the conference?

An advertisement appears in your journal this week for the head of the engineering department of a large technical school in the provinces. "A commencing salary of £160 per annum will be paid"!!

This is only one. There are scores of advertisements of this type appearing in the technical journals at this time of the year. The majority of them require workshop, college, and teaching experience. £160 is rather above the average starting salary!!

Is this a good thing for the engineering profession? No one can possibly say that it is. The conference may sit and discuss for a month the best subjects to be taught; but until the salaries of engineering teachers are raised high enough to attract good men to do the teaching, the discussion will be useless.

Under present conditions, the college man only turns to teaching as a last resource, and then is always waiting and watching for an opportunity to leave it. Can good tuition be given under such circumstances?

I personally know of a case—another provincial town—where the salary offered was so miserably inadequate that the only person the school authorities could obtain to take charge of the engineering department was a man straight from the engine-room of a merchant boat, with no college training and no diploma. He had some of the best material in the country to teach, but, fortunately for the students, he was "fired" after a short time. No blame to him. He tried and failed. He may have been a good engineer, but he certainly was not a teacher of engineering. But he should never have had the opportunity to try. The salary offered should have been large enough to attract men with qualifications that would have brought ridicule on his application. At present the men with the necessary attainments go to the Patent-office or other places and do clerical work, with the pleasant prospect of a certain salary of £450. Their few unfortunate fellow collegians who were foolish enough to be attracted to the teaching profession are dazzled by the prospect of an ultimate salary of £200.

The London County Council is the worst offender—by com-

parison—in this respect. Their technical school teachers, with workshop, teaching and college experience, are offered a maximum salary of £200; their secondary school teachers, with no killing evening teaching, all rise to £300. The London County Council, at the same time, have hundreds of clerks with salaries rising to £400 or more. They recently advertised for a gymnastic instructor to help with clerical work at a secondary school—salary rise to £250. Is it strange under these circumstances that teachers of engineering feel that their youth has been wasted in training for so poorly paid a profession? A salary of £200—after five or six years in the workshop with continual evening study and no recreation, three or four years' "grind" at college and five years plodding—killing work trying to "keep up" evening classes!!

As far as I can understand, the I.C.E. conference will not deal with the ordinary evening engineering student, but at the same time is not this part of the subject worthy of discussion? Can anyone deny that it is a bad thing for engineering as a whole to turn away good material by offering salaries that a bank clerk or average music-hall artiste would sneer at—to say nothing of a gymnastic instructor!!

London, June 19th. HOPELESS.

NEW PUMPING STATION AT WALTON-ON-THAMES.

SIR,—As a specialist in centrifugal pumping machinery, I cannot refrain from making some comments on the pumping plant at the Walton station, described on page 616 of your issue of the 16th inst. I do not wish to suggest there is any discredit due to either contractor or sub-contractor, but intend just to express astonishment that such an important plant could be installed on such lines, and to record my wonder as to how it could have been fixed up. I refer particularly to the four units for lifting water from the Knight and Bessborough reservoirs into the Barn Island reservoir. Here we have a slow-speed triple-expansion marine engine at 120 revolutions per minute on a land job. The economy of the engine no doubt is high, and it is right enough to seek high economy on a plant intended for continuous duty. This engine is connected to a centrifugal pump, and the result is a two-stage pump of special design with impellers 8ft. 3in. diameter. Now, to make such a pump efficient would result in a very expensive machine, and to keep the cost reasonable the pump builders are forced to an inefficient design. There can be no denying that the pump illustrated is inefficient, compared with what might have been done without restrictions of any sort—such as speed, &c. A glance at the section indicates this clearly; or, if further proof is required, the fact that the peripheral speed is as much as $1.185\sqrt{2gH}$ is sufficient to show conclusively that the designers did not anticipate a high efficiency. Personally I have grave doubts whether 70 per cent. efficiency would be attained.

Now, for a land job of 500 brake horse-power and for continuous service this is not good, and when we consider that there has been no economy in first cost this is bad. We are entitled to look for models of best current practice in such public works as the one under consideration, and I venture to assert that the above combination does not represent good modern practice at all.

It may be that in the immensity of the schemes that the Water Board is responsible for, the mere mechanical part is insignificant, also it surely is a fact that an engineer familiar with the best water engineering practice is not the engineer to select the finest example of economical current practice in any mechanical engineering speciality. However, specialised advice is obtainable at a merely nominal price, and I must say I do not see any justification for such an oddity of a machine as we see here.

The centrifugal pump is essentially a quick-revolution machine, the marine type engine is the reverse—note the combination. The only legitimate combination of an open type engine and centrifugal pump is where the total head is quite low—here we have 64ft., which is not at all a low head.

Most emphatically, a quick-revolution enclosed engine with forced lubrication should have been selected when a speed of 375 revolutions per minute could have been obtained. The pump could then have overcome the head of 64ft. in one stage with a single impeller of not more than 3ft. 6in. diameter. Guide vanes could be dispensed with, and the efficiency of this pump could easily be not less than 75 per cent. The weight of this set would be half of the one installed, and evidently would be considerably cheaper.

The waterworks engineer is accustomed to slow-speed plunger pumps and, to the writer, this plant stands as an expensive monument to the mistaken notion of carrying over experience gained with one type of machine to another essentially different type.

Trusting you will not consider this by any means unfriendly criticism. OWEN A. PRICE.

Glasgow, June 19th.

"THE PARENT'S POINT OF VIEW."

SIR,—Your leading article is interesting, and as I have been through "the mill," and as I am responsible for the engineering education of my boy, who has nearly passed through "the mill," my experience may be of interest from "the parent's point of view." When I left school at the age of 16½, my father offered to send me to the University or "into the works." I had my choice. I chose the latter, and have never regretted it.

My start in the works was rather unfortunate for the first year, since I was put to work on the sandwich system. I did my six months' works, and throughly enjoyed it, and then a miserable six months' college, much to my disgust. At the end of this period I had sense enough to feel that at the end of my apprenticeship I should be neither fish nor fowl or good red herring as a mechanic, and I objected to further experiment in this direction. I also had experience of living in certified lodgings, and my landlady, poor soul, had of course to report to the principal of a college. This she did more than once, since I preferred to spend the night occasionally helping an engineering friend to scale his boilers and to repair broken-down machinery. The principal of course went for me in the usual professorial way, not understanding my inborn interest in mechanical science, and naturally thought I was going to perdition. I then went my own way. For six solid years I lived in the works, attended some evening classes, and eventually obtained a position sufficiently well paid to make me independent of my father. This happened nearly twenty-eight years ago. Since then I have reason to be satisfied with my career.

The point I wish to make is that the mechanical engineer must, in my opinion, be a works' trained man—he must spend his whole time in the works, and the day cannot be too long. If an apprentice is wise enough to attend evening classes of his own free will, so much the better for him.

The sandwich system is wrong. A boy goes to the works direct from school; he sees no harm in the dirt of the shop; he enjoys his work and does not consider it *infra dig.* to associate with the good fellows the average working men usually are. The same boy then goes to college, he wears a black coat, he learns to despise the dirt of the works, and at the end of the six months' course is far too big a swell to settle down to 6 a.m. work and associate with his old friends of six months ago. Another objection is that the six months in the works is sufficient to lose touch with the previous college course, and *vice versâ*, so the ultimate result is unsatisfactory.

I am sorry to think there is a possibility that the training of the present-day mechanical engineer will not produce such men as Whitworth, Stroudley, Webb, and many others I could name. Too much is, in my opinion, being left to the professor, and too little to practical experience in the works.

As regards the question of certified lodgings, such restrictions only lead to deceit. A boy must be thrown on his own sooner or later—the sooner the better. Why not insist upon Sunday-school attendance as well?

I enclose my card, from which you will see that I ought to know something of the subject you discuss.

June 26th. M. INST. C.E.

THE CALORIMETER IN THE POWER-HOUSE.

SIR,—In a leading article in your issue of June 16th you discuss in your usual practical manner the question of the use of the calorimeter in the power-house, and very truly state that the point of greatest interest to the steam producer is how to get the largest possible quantity of steam in return for his expenditure on coal. You also ask for facts showing any favourable influence on the monthly coal bill which may be evident since the aid of the chemist was called in.

The reply to this may very well be left to Mr. Kershaw, the writer of the paper which led to your article, whose name is so well known to all who take an interest in the question of combustion of fuel and fuel economy.

It may not here be out of place, however, to recollect that to the chemist we owe the means of effecting one other considerable item of economy in the boiler-house, for it was he who first called attention to the fact that so much was to be learnt from an investigation into the composition of the flue gases leaving the boiler, and that if we could discover the percentage of CO_2 contained therein we should have reliable knowledge as to whether the calorific value of the fuel burned in the furnace was being used in the best possible manner, or whether it was being to a certain, and perhaps a large, extent wasted.

We must not forget that we owe this debt of gratitude to the chemist, even though the matter since those earlier days has been taken out of his hands, for all up-to-date steam users know that it is now possible for them to install small, simple, and strong instruments, viz., automatic CO_2 recorders, which will give them reliable information in a form for present or future reference. To these "a pecuniary meaning can be attached," as many will bear witness.

Since you infer that facts are of the utmost value in matters of this kind, I enclose herewith copy of a letter recently written by a borough surveyor and engineer in the Midlands, stating that the information given him by a CO_2 recorder, as to the nature of the firing and the condition of the brickwork, had enabled him to effect an economy of 10 per cent. on his year's coal bill. As you will see, this is not the result of an eight hours' test, where errors are liable to creep in, but of twelve months' running—and, moreover, the plant in question being at a pumping station it is a specially favourable case for measuring the load absolutely and making definite comparisons.

This letter, however, is unfortunately not for publication, as I have not at the present moment the necessary permission, although to quote your concluding words "no more potent means of effecting improvements can be found than the free interchange of information."

At the opening of the recent Chemical Engineering Exhibition in London great stress was laid by several speakers on the importance of co-operation between the chemist and the engineer, and this question of flue gas analysis affords one instance of beneficial results accruing therefrom.

Leicester, June 21st. ARTHUR E. JONES.

CONSTANTS.

SIR,—I am preparing for publication a work containing, as far as possible, a complete list of simple and compound "constants" for commercial, engineering, and scientific calculations. Latimer Clark's well-known book, "Metric Measures," gives practically all the simple constants, but in every trade and profession there has been worked out individual compound constants which considerably simplify solutions. May I ask your readers if, having such, they will send the formulæ to me, and, if original, the name of the author will be duly acknowledged in the print. The use of these constants is proposed in connection with a new form of tables which gives on inspection logarithm constants common to units of English measures of length, weight, and money, converting into all metric and foreign measures, and dealing by one set of simple additions with every possible question. ALFRED STEVENS.

London, N.W., June 28th.

FORTHCOMING ENGAGEMENTS.

TO-DAY.

PHYSICAL SOCIETY OF LONDON.—The Imperial College of Science. "On the Effect of a Narrow Saw-cut in the Edge of a Conducting Strip on the Stream Lines in the Strip and on the Resistance of the Strip," Professor C. H. Lees, F.R.S. "The Capacity Coefficients of Spherical Electrodes," Dr. A. Russel. "Exhibition of the Benkö Primary Battery," Mr. W. R. Cooper. 5 p.m. This meeting takes the place of the one previously arranged for June 23rd, which is cancelled.

SATURDAY, JULY 1ST.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to Messrs. George Kent's Hydraulic Engineering Works, Biscot-road, Luton, and the Straw Hat Factories of Messrs. Dillingham and Son, or of Mr. F. E. Shoosmith, both in Upper George-street, Luton.

MONDAY, JULY 3RD, TO SATURDAY, JULY 8TH.

INSTITUTION OF NAVAL ARCHITECTS.—Jubilee meetings. For programme see page 627 *ante*.

WEDNESDAY, JULY 5TH.

THE NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION.—Institution of Electrical Engineers, Victoria Embankment, W.C. Special general meeting. 3 p.m. A Council meeting will be held at 12 noon.

THURSDAY, JULY 6TH.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Conversazione to be held at the Natural History Museum, S.W. 9 to 11.30 p.m.

THE NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION.—Balfour House, Finsbury-pavement, E.C. Council meeting will be held at 2.30 p.m.

WEDNESDAY, JULY 19TH.

THE STEPHENSON SOCIETY.—Visit to Swindon Locomotive and Carriage Works (Great Western Railway).

THURSDAY, JULY 20TH.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Visit to the Great Eastern Railway Locomotive Works at Stratford, E. Leave Liverpool-street 1.52 p.m. (platform No. 13).

MONDAY, JULY 24TH, TO SATURDAY, JULY 29TH.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Zurich Meeting, 1911. For programme see page 630 *ante*.

SATURDAY, JULY 29TH, TO SATURDAY, AUGUST 5TH.

JUNIOR INSTITUTION OF ENGINEERS.—Summer Meeting in East Anglia. For programme see page 653.

THURSDAY, AUGUST 3RD, TO MONDAY, AUGUST 21ST.

GEOLOGISTS' ASSOCIATION OF LONDON.—An Excursion to the Bergen District, Norway. Leaving King's Cross on August 3rd by special boat train for Hull.

SATURDAY, SEPT. 9TH, TO WEDNESDAY, SEPT. 20TH.

GEOLOGISTS' ASSOCIATION OF LONDON.—September Long Excursion. The first part of the excursion will be devoted to a study of the Geology of Lochaber, including Glens Nevis, Roy and Coe, and Fort William will be the headquarters. The second part of the excursion will be devoted to the Geology of the Broadford district of the Island of Skye, and the headquarters will be at Broadford. Full particulars of excursion may be obtained from Mr. Alfred D. Young, 17, Vicars-hill, Lewisham, S.E.

WEDNESDAY, SEPT. 13TH, THURSDAY, SEPT. 14TH, AND FRIDAY, SEPT. 15TH.

THE INSTITUTION OF MINING ENGINEERS.—Cardiff. Annual general meeting. Further particulars later.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Approaching Quarterly Meeting.

THE iron trade quarterly meeting is fixed for July 13th, and to this fixture makers are now mostly looking. It is hoped that increased buying may then be observable, and in some branches this is almost certain to occur. The bar iron firms started the week earlier than other concerns, and prices are fairly steady at £6 5s. to £6 7s. 6d. (local deliveries) for merchant bars, and £6 15s. at the ports for North Staffordshire qualities. Second-grade best bars are £7, and common £5 16s. 3d. to £5 17s. 6d., about. Hoops continue at £7 to £7 10s., and tube strips at £6 10s. to £6 12s 6d. Galvanised sheets are £4 15s. f.o b., though firms on the coast are believed to be selling at as low as £10 12s. 6d., and even in some cases £10 10s.

Pig Iron.

The pig iron trade suffers the disadvantage that this week, although the finished ironworks have resumed operations after the suspension for the Coronation holidays, the extent of activity has been only a very limited amount. The consumption of raw material has not, therefore, been on an average scale. Iron buying is largely postponed until the quarterly meeting, when, however, a fair number of contracts are likely to be placed. Prices are rather easier, owing to lower prices for coke by 1s. to 1s. 6d. per ton, of which pig iron buyers are sure to take full advantage. South Staffordshire common forge iron is nominal this week at 49s. per ton, part-mine iron 50s. to 50s. 6d. per ton, and best all-mine 85s. to 90s. Derbyshire forge iron is 50s. to 51s. delivered Birmingham or equal, but Northampton iron is as low as 47s. to 48s. per ton.

Steel Trade.

There is little new to record of the steel trade, but the best position is certainly occupied by rolled material, the question of foreign competition entering into makers' calculations much less in this branch than in raw material. The works are all well engaged in rolled steel—indeed, in some directions, are behind-hand with deliveries. Values keep at:—Angles, £6 12s. 6d. to £6 15s.; girder plates, £7 2s. 6d. to £7 5s.; ship plates, £7 to £7 10s.; and joists, £6 10s. Raw steel prices are £4 15s. now for native Bessemer bars and £4 17s. 6d. to £5 for Siemens qualities, Continental salesmen are rather less active in pushing business on the Birmingham Exchange than they were a while back.

Wrought Iron Tube Trade.

The wrought iron and steel tube trade does not make any improvement, owing mainly to the continued prevalence of keen competition among the makers. Nothing further seems to have been heard of the proposal to reconstitute the Makers' Association, which collapsed in 1908, although in the early part of the year the proposal seemed to be taking shape. It was then stated that the negotiations had made considerable progress, and that for some time a firm of accountants had been engaged in investigating the books of the firms willing to join for the purpose of ascertaining their average production over a period of years. Some of the makers also early this year announced that "they were quite prepared to meet their competitors half way on the question of increasing prices as to yield a working margin profit."

Railway Material for China.

Railway material firms have received this week, with considerable expectation, a report that the Chinese Government is sending to Europe a commission of three experts to make a selection of the locomotives and rolling stock to be employed on the new State lines. It is stated to be probable that the locomotives and passenger carriages will be ordered from this country, but that the goods wagons will be placed in America. It is added that it has been customary for some time for the Chinese Government to secure its freight wagons in the United States.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

A More Hopeful Feeling.

So far as pig iron was concerned the month has been uneventful in character. The Whitsuntide holidays, followed by the Coronation, has had anything but a stimulating effect on business, although towards the close of June there is a much better undercurrent to note. Taken on the whole, the tone throughout the month has been very even. In English brands, with the exception of Middlesbrough, which closed rather dearer, there was no change to note. In Scotch, both Gartsherrie and Glengarnock were firmer, and Eglinton was also steady. Hematite, both East and West Coast, also showed little fluctuation. A pleasing interlude during the afternoon of Tuesday on the Iron Exchange, was the singing of "God Save the King," which was heartily rendered by all members present on the "Boards." Finished iron and steel shows little change.

Copper.

While sheets show an advance of about £1 as compared with the opening of the month, tough ingots and best selected have advanced about 30s. per ton. With the exception of copper and brass tubes and condenser, which ruled unchanged, other sorts showed an advance of ¼d., and yellow metal ⅛d. per lb. on the beginning of the month.

Sheet Lead and Tin Ingots.

Sheet lead continued unchanged, but tin ingots after fluctuating closed about £3 per ton lower on the month.

Quotations.

Pig iron: Lincolnshire, No. 3 foundry, 53s.; Staffordshire, nominal, 53s. 6d. to 54s. 6d.; Derbyshire, 53s. 6d. to 54s; Northamptonshire, 54s. 6d. to 54s. 9d.; Middlesbrough, open brands, 55s. 7d. to 55s. 10d., according to delivery. Scotch: Gartsherrie, 61s.; Glengarnock, 59s.; Eglinton, 58s. to 58s. 6d., delivered Manchester. West Coast hematite, 64s. to 64s. 6d., f.o.t.; East Coast ditto, 62s. 6d. to 63s., f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 57s.; Eglinton, 56s. to 56s. 6d. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 58s.; Eglinton, 57s. to 57s. 6d. Finished iron: Bars, £6 15s.; hoops, £7 7s. 6d.; sheets,

£8 to £8 2s. 6d. Steel: Bars, £6 10s. to £7; Lancashire hoops, £7 7s. 6d.; Staffordshire ditto, £7 7s. 6d.; sheets, £8 to £8 5s.; boiler plates, £7 15s.; plates for tank, girder, and bridge work, £7 to £7 5s.; English billets, £5 to £5 5s.; foreign ditto, £4 10s. to £4 12s. 6d.; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £71; tough ingots, £61; best selected, £61 per ton; copper tubes, 8¼d. to 8½d.; brass tubes, 6½d.; condenser, 7½d.; brazed brass tubes, 8½d.; rolled brass, 6½d.; brass wire, 6¾d.; brass turning rods, 6¾d.; yellow metal, 6d. to 6¼d. per lb. Sheet lead, £16 to £16 5s. per ton. English tin ingots, £197 per ton.

The Lancashire Coal Trade.

There is little of interest to note, and although the strike is affecting the deliveries from the Yorkshire coalfields it has up to now had practically little effect on the Lancashire trade. A few contracts were reported as having been put through at 3d. to 6d. per ton under the expiring contracts.

BARROW-IN-FURNESS, Thursday.

Hematite Pig Iron.

The past week has seen no alteration for the better in the demand for hematite pig iron. Consumers' wants are not many, and only small orders are being given out to smelters. The make of iron is about the same, there being eleven furnaces in blast in North Lancashire and thirteen in West Cumberland. In the latter area there has been a settlement of one labour trouble, and there are prospects of brisker times there when the steel works again get into operation. In the meantime more iron is being produced than sold, and the stores in makers' hands have been on the increase. Warrant stores, however, remain much the same, representing in the aggregate just over 39,000 tons. Prices are nominal, and mixed numbers of Bessemer iron are set down at 63s. per ton net f.o.b. For special sorts of iron there is a steady request, and the quotation runs from 66s. to 69s. per ton. Warrants have been idle for some time and are not often quoted. They are at 61s. 9d. per ton net cash.

Iron Ore.

There is no change to note in the iron ore trade. A steady business is being done locally, although this trade is not so good as it was, by reason of the fact that smelters are not pressing the output. On general account, except in the very best grades, there is not much doing, except on account of Scotch makers of iron, who continue to take supplies of Furness and Cumberland ores. Prices run about the same with good average sorts at 10s. to 12s., and the best ores are at 19s. 6d. per ton net at mines. The demand for Spanish ores is steady, but not over large, and the deliveries are easy. The current value of this class of ore is 20s. per ton delivered for highest qualities.

Steel.

The steel trade remains much the same commercially. There is a steady but by no means brisk demand for rails. Requirements both on home, colonial, or foreign account are only moderate at present. Heavy sections are at £5 12s. 6d. to £5 15s. per ton. Light rails represent a quiet business at £6 5s. per ton. At Barrow the rail mills are at work again this week, but the Moss Bay Works remain idle. Repairs are being carried out at these works, where some pretty good orders are held. Nothing is being done in steel shipbuilding material, and the demand for tin-plate, bars, hoops, &c., is fair.

Shipbuilding and Engineering.

There is a brisk state of affairs to report in both these trades. The contracts are being pushed forward. H.M.S. Dartmouth, one of the new type of destroyers, is almost completed, and this week has been placed in dry dock preparatory to undergoing her trials. A Chinese cruiser is shortly to be launched from the Barrow yard.

Shipments.

The shipping trade is very much depressed. Last week only 1605 tons of iron and 550 tons of steel left West Coast ports, a decline of 10,110 tons. The shipments of iron and steel this year stand now at 244,908 tons, a decrease of 94,306 tons, last year's figures being 339,214 tons.

Fuel.

The demand for coal is easy. Good steam sorts from Lancashire or Yorkshire pits is quoted at 11s. to 15s. 6d. per ton. East Coast coke is in lessened demand at 20s. 6d. per ton delivered.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

General Conditions.

BUSINESS in the iron and steel markets can scarcely be said to have recovered yet from holiday influences, and the quietude usually experienced at the half-year is very noticeable at present. Both buyers and sellers are adopting a waiting attitude, and, with the market merely "marking time," no variation in prices can be recorded. Although the local steel makers have undoubtedly a very fair quantity of work on their books to start the second half of the year, they complain a good deal about the unremunerative level of prices and the keenness of competition. This, of course, refers chiefly to general trade, and not to the manufacture of armaments and other specialities, where conditions remain very satisfactory. It is rather early yet to speak with any confidence of trade prospects, but there is undoubtedly a general feeling that a considerable improvement will take place next half-year, for it is thought that the rather marked falling off in certain lines recently can only be temporary.

The Coal Trade.

The position of the coal market has not been very seriously affected so far by the suspension of shipping at Hull and other ports, for the severe curtailment of outputs during the holidays cleared off stocks at the pits. A collapse of the strike would quickly put matters on an improved footing, but at the present time the colliery position is not bettered by what is taking place. Despite these untoward events, which have come at a very inopportune moment, collieries are maintaining prices at 8s. 6d. to 8s. 9d. per ton for best South Yorkshire hards, for it is thought that the seamen's and dockers' strike cannot last long. There is a fair industrial consumption, and orders are steadily improving now that the holidays are out of the way.

House Coal.

There is little or no movement in the house coal market. Some tempting offers of "spot lots" of soft coals from stocks fail to attract much response from merchants, who seem to have little inclination to enter into speculative buying. Contracts are only being made slowly. Prices are well held for the time being, and there seems to be little prospect of any lower rates being quoted.

Slacks.

The demand for slacks is recovering the ground lost during the holidays, and with the short time that is now being worked at the pits supplies are none too large. Some of the largest producers are well sold under contracts, and are being pressed for deliveries. Quotations:—Best washed smalls, 5s. 6d. to 6s.; best hard slacks, 5s. 6d. to 5s. 9d.; seconds, 4s. to 4s. 3d., all per ton at pit.

Gas Coal.

The renewal of gas coal contracts is proceeding steadily, and the bulk of the business is expected to be arranged next month. Contract prices remain on the basis recently mentioned, and generally about 3d. to 6d. under last year's rates.

Pig Iron.

As already indicated, there is very little business to record in the pig iron market, either for common irons or hematite. Local consumers are well covered for the next two or three months. Deliveries are on a reduced scale. Makers are quoting steady prices, although Derbyshire forge prices are not very strong, some iron having been sold well below 48s. net delivered. Quotations: Lincolnshire, No. 3 foundry, 50s. 6d.; ditto forge, mottled and white, 49s. 6d.; ditto basic, 52s.; Derbyshire foundry, 49s. 6d. to 50s. 6d.; ditto forge, 47s. 6d. to 48s. 6d.; all per ton net delivered Sheffield or Rotherham. East Coast hematite, mixed numbers, 68s. 6d. net and West Coast, 76s. to 77s., less 2½ per cent. discount.

The Steel Trades.

Although most of the large steel works have fully resumed operations this week, some others are partially idle for stocktaking and the effecting of repairs, but, generally speaking, the local trade situation has shown no weakening. Regular working is reported at the armament works, the steel foundries are busy, and makers of crucible steel products, such as saws and other tools, twist drills, &c., are extremely active on export account. The file trade is much better employed than for a long time past. Prices of Swedish rough bars for crucible steel making have been further advanced to 25s. per ton in excess of the old rates.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

TRADERS were in good hopes that business in the Cleveland pig iron industry would become brisker after the holidays, but unfortunately they are disappointed, and the present week is one of the quietest that has been known for a long time. There is quite an indisposition to do any business for forward execution, and no one needs to buy for prompt. Cleveland pig iron warrants have dropped as low as 46s. 2½d. cash buyers, that being only 6d. above the minimum of the year, and about 4s. below the maximum. Such a poor price was not known at any time last year, and as consumers think there is a probability of still lower prices, they are holding back. The market is further weakened by the unsatisfactory shipments and stocks. Only 88,269 tons of pig iron had been shipped from the Cleveland district this month up to Wednesday night, against 111,437 tons in May to 28th, 108,272 tons in June, 1910, and 91,404 tons in June, 1909—a very poor display indeed, and much below what was expected. The falling off is due mainly to the strike of seamen, for there are not enough steamers available to take away all that is due for delivery, and there is iron stored in the makers' yards which would have been in the hands of consumers if this trouble in the shipping trade had not appeared. It has also led to an increase of the stock of Cleveland pig iron in Connal's public store, whereas over the first three weeks of June the stock was decreasing. Connal's stock on the 28th was 595,130 tons, an increase for the month of 1130 tons. In such circumstances no one is in a hurry to anticipate requirements, and practically nothing needs to be bought for prompt. For No. 3 Cleveland G.M.B. pig iron the price has dropped to 46s. 6d. per ton for prompt f.o.b. delivery, though second hands have sold small lots at 46s. 4½d. per ton. No. 1 is at 50s., Nos. 4 foundry and 4 forge at 46s., and mottled and white at 45s. 9d. per ton, all for prompt delivery. The market is so unsettled, and business so slack, that it is almost impossible to name reliable prices for forward delivery. Speculative operations are fully as slow as ordinary business.

Hematite Pig Iron.

While there is improvement in demand to be reported, and encouraging prospects likewise, yet makers do not succeed in advancing prices. As a rule producers are well off for orders, and have but small stocks, so that they should be in a position to secure more money for their iron. There is little, if anything, to be made out of present prices. The makers' quotation for mixed numbers East Coast hematite pig iron is 62s. per ton for early delivery, but the merchants and some ironmasters will accept 61s. 6d. The stoppage of the steel works for the Coronation holidays has not had any ill effect upon the hematite iron market, though the steel works were stopped three days and the blast furnaces one day. The production of hematite iron is not in excess of requirements, and makers have no difficulty in disposing of all they can turn out. It cannot be reported that there have been any sales of Rubio ore lately, and there is really no business to fix prices. Merchants will not ask or accept, except in rare cases, anything below 20s. per ton ex-ship Tees for good Rubio; but consumers offer no more than 19s., and affirm that they could get small lots at that. Evidently the time has not yet arrived when the ironmasters must come into the market to negotiate for supplies. They have still good stocks and satisfactory contracts on their books for ore. Ironmasters are getting some relief in the cost of coke, for it is relatively cheaper than pig iron, and is lower than it has been for several years, there being too much of it made, and the surplus is strongly pressed upon the market, as coke manufacturers will do much to avoid accumulating stocks. It is easy to buy good furnace coke at 14s. 6d. per ton delivered at Middlesbrough works, and even 14s. will not be refused by some sellers.

Manufactured Iron and Steel.

The producers of finished iron and steel give good accounts of business, and, generally, they are better off for orders than they have been for the last three years or more—indeed, some have never had so many contracts on their books at a time as they have at present, and this enables them to keep up their prices. This situation gives some confidence to traders, and leads to the expectation that the pig iron market must before long have a more favourable experience than at present, for the finished branches cannot continue to improve without having a good influence on the market for raw materials. The greatest improvement is in the rail trade; all the works producing rails are fully occupied this week, after having been stopped three days last week for the Coronation holidays. Inquiries are more numerous than for a long time, especially on Indian account. Heavy steel rails are quoted at £5 12s. 6d. net f.o.b. Railway chairs are likewise in more request, and producers are able to get £3 12s. 6d. net f.o.b. For steel sleepers the demand is rather slack, even on export account. Sales on home account have been poor for a considerable period, but the quotations still range between £6 7s. 6d. and £6 12s. 6d. per ton net f.o.b. Steel ship plates are firm at £6 15s., iron ship plates at £6 12s. 6d., steel ship angles at £6 7s. 6d., and iron ship angles at £7, all less 2½ per cent. f.o.t. Steel bars are at £6 5s., iron bars at £7, steel hoops at £6 12s. 6d., steel strip at £6 10s., steel sheets (plain) at £7 7s. 6d., steel joists at £6 7s. 6d., all less 2½ per cent. f.o.t. Galvanised and corrugated steel sheets, which are in excellent demand, are at £10 15s. for 24 gauge, less 4 per cent. f.o.b., notwithstanding that lower rates are being taken in other districts. Manufacturers in this district are so well off that they can afford to hold out for better prices.

The Three-shift System at Collieries.

There is likely to be serious trouble at the Northumberland collieries with regard to the three-shift system which was introduced when the Eight Hours Act came into force last year. The three-shift system has never been popular with the miners, who claim that it destroys their home and social life. The executive of the Northumberland Miners' Association has decided to press for its abolition, and has had several conferences with the employers without arriving at any compromise. Last Saturday the Miners' Council declared definitely that they would strongly oppose the continuance of the three-shift system, and to advise the members to tender fourteen days' notice to terminate their engagements under the existing eight hours agreement. A ballot is to be taken on the subject, and if it is favourable to the abolition the Miners' Federation of Great Britain is to be asked to agree to a national stoppage of collieries to support the abolition of the system in Northumberland. It will take three weeks to carry out the ballot, and it seems likely that in five weeks there will be a general strike in the Northumberland coalfield. The Durham Miners' Eight Hours Committee are also agitating for an alteration in the county working agreement. The abolition of the three-shift system is not so strongly insisted upon; indeed, nineteen of the pits were working under it before the Eight Hours Act came into operation, these being the largest in the county, and producing one-fourth of the total output of the county. One colliery—the Murton—is worked under the four-shift system. The men's committee is seeking to secure a modification in the matter of shifts. Out of 200 Durham collieries 140 are working under the three-shift system.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Pig Iron Warrant Market.

THERE has been a quiet and occasionally an easier feeling in the Glasgow warrant market this week. A tendency to deal in month iron has been noticeable both this week and last. The market has been influenced to a comparatively small extent by American advices. These came strong towards the end of last week, but have again become somewhat uncertain in the last day or two. A feeling of unsettlement in considerable sections of the labour market is not without its influence on the iron trade, indirect, no doubt, but still none the less actual. Since last report, business has been done in Cleveland warrants at 46s. 6d. to 46s. 3½d. cash, 46s. 8d. to 46s. 6½d. one month, and 46s. 11d. three months.

Scotch Pig Iron Trade.

The inquiry for Scotch pig iron has been moderate, and perhaps rather less than had been anticipated. Notwithstanding the present comparatively low prices, consumers are apparently purchasing only from hand to mouth; and there is, generally speaking, no great pressure for delivery. There are 83 furnaces in blast in Scotland, compared with 85 at this time last year. Makers' prices have been steady. Govan and Monkland at Glasgow are quoted f.a.s. Nos. 1, 56s.; Nos. 3, 56s.; Carnbroe, No. 1, 60s.; No. 3, 56s.; Clyde, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Gartsherrie and Calder, Nos. 1, 61s.; Nos. 3, 56s.; Summerlee and Langloan, Nos. 1, 63s.; Nos. 3, 58s.; Coltness, No. 1, 82s.; No. 3, 58s.; Eglinton, at Ardrossan or Troon, No. 1, 56s.; No. 3, 55s.; Glengarnock, at Ardrossan, No. 1, 64s.; No. 3, 59s.; Dalmellington, at Ayr, No. 1, 57s.; No. 3, 55s.; Shotts, at Leith, No. 1, 62s. 6d.; No. 3, 58s.; Carron, at Grangemouth, No. 1, 63s.; No. 3, 58s. per ton. The shipments of Scotch pig iron in the past week amounted to 3316 tons, against 3533 in the corresponding week of last year. No iron was sent to the United States, Italy, Russia, Belgium, Spain, or Portugal, but there was despatched to Australia 500 tons, Germany, 110; India, 65; Canada, 43; South America, 25; France, 10; Holland, 50; China and Japan, 265; other countries, 145; the coastwise shipments being 2103 tons, compared with 1462 tons in the corresponding week. Scotch users of Cleveland pig iron have not been taking so much iron as they did earlier in the season. The arrivals at Grangemouth from Middlesbrough and district in the past week reached 7268 tons, being 3750 tons less than in the corresponding week of 1910.

Finished Iron and Steel.

The new business in finished iron and steel is of moderate proportions. Makers of malleable iron have had fair employment, in most instances, but new orders are difficult to obtain. The official quotations are still on the basis of £6 10s. for crown bars, less 5 per cent., but it is alleged that orders have been accepted 5s. to 10s. below that figure. In the steel trade, the state of employment is not what could be desired. There has been comparatively little fresh business offered, and shipbuilders are not keeping the works going with specifications in a satisfactory manner. Buyers are not prepared to pay current rates for steel if they can possibly stave off business. The figures quoted are £6 10s. for steel angles, £6 17s. 6d. for ship plates, £7 10s. for steel bars, and £7 12s. 6d. for boiler plates, all less 5 per cent. discount for delivery in the Clyde district. Ironfounders and engineers report that while, in not a few cases, fairly well provided for at present, the inquiry for new work is comparatively quiet. There are inquiries going the round for a variety of iron and steel material for export, and it is hoped that some orders may eventually result from these to Scotch makers.

The Coal Trade.

There is a moderate business being done in the coal trade, but shipments are being obstructed this week at some of the ports by strikes of dock labourers, and the labour revolt in the shipping trade generally is having an unsettling effect on business. Household and manufacturing qualities of coal for home use meet with a fair sale, about former prices.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THE business last week was of a very slight character. When the certainty of a seamen's strike was manifest, fears were expressed that some of the offices would be closed, and that a ruinous state of things was likely, but, happily, the greatest difficulty proved to be the delay of a tide or two, and the regular course of shipping was not materially affected. Best Admiralties have been largely sold, and seconds and smalls were in fair supply. Monmouthshire large has been coming in well, and the continuation of the strike seems, on the whole, to bring these coals more into prominence. Last week, for example, the quantity of coal shipped to foreign destinations was 50,119 tons, and coastwise 10,457, and but for the Coronation holidays these would have been larger. Forward business is chiefly affected, but July business is well secured, and this is regarded as indicating a belief that a better condition is at hand, however alarming the reports and rumours are. Small coals are in strong demand, and sellers are holding firmly to quotations. Mid-week there was a fuller inquiry, especially for July and August delivery. For prompt shipment conditions were steady. Buyers are evidently taking note of the action of the Northern miners in the question of the three shifts, and the possibility of a strike in August or September is not without an influence upon business. Latest: The Admiralty has continued to ship heavily, and best steam coals are very scarce, and full figures are quoted for seconds. Drys are steady; house coals quiet; pitwood steady; patent fuel firm.

Latest Quotations, Cardiff.

Best steam, 18s. 3d. to 18s. 9d.; best seconds, 16s. 9d. to 17s. 6d.; ordinaries, 15s. to 15s. 6d.; best drys, 16s. to 16s. 9d.;

ordinary drys, 14s. 9d. to 15s. 6d.; best washed nuts, 14s. 6d. to 15s.; seconds, 13s. 6d. to 14s.; best washed peas, 12s. 6d. to 13s. 6d.; seconds, 11s. to 12s.; best bunker smalls, 10s. 9d. to 11s.; best ordinaries, 10s. 3d. to 10s. 6d.; cargo smalls, 9s. to 9s. 3d.; inferiors, 8s. to 8s. 6d.; best Monmouthshire black vein, 15s. 9d. to 16s.; ordinary Western Valleys, 15s. 3d. to 15s. 6d.; best Eastern, 14s. 3d. to 14s. 9d.; seconds, 14s. to 14s. 3d. Bituminous coal:—Very best households, 17s. to 18s.; best ordinaries, 14s. 6d. to 16s. 6d.; No. 3 Rhondda, 17s. to 17s. 6d.; brush, 13s. 3d. to 13s. 9d.; smalls, 10s. 6d. to 10s. 9d.; No. 2 Rhondda, 11s. 9d. to 12s. 3d.; through, 10s. 3d. to 10s. 6d.; smalls, 8s. to 8s. 6d. Patent fuel, 16s. 9d. to 17s. 6d. Coke: Special foundry, 24s. to 25s.; foundry, 18s. to 20s. 6d.; furnace, 16s. to 17s. Pitwood, ex ship, 18s. 6d. to 19s.

Newport, Mon., Coals.

Shipments of coal last week were affected by the festivities; total confined to 50,119 foreign and 10,457 coastwise. Tonnage mid-week difficult; sellers holding forward firmly; smalls not quite so firm. Latest:—Very best black vein, 15s. 6d. to 15s. 9d.; Western, 15s. to 15s. 3d.; Eastern, 14s. to 14s. 3d.; other sorts, 13s. 6d. to 13s. 9d.; best smalls, 8s. 6d. to 8s. 9d.; seconds, 8s. to 8s. 6d.; inferiors, 7s. 9d. to 8s. Bituminous: Best households, 15s. 6d. to 16s. 6d.; seconds, 14s. to 15s. Patent fuel, 16s. to 17s. Coke: Foundry, 18s. to 20s.; furnace, 16s. to 17s. Pitwood, ex ship, 18s. 6d. to 19s. Coal price f.o.b., less 2½ cash 30 days.

Swansea Coals.

The Coronation festivities, seamen's strike, and the continuance of the Mid-Rhondda trouble affected all ports in a greater or less degree. Swansea suffered a decrease of 23,000 tons, but it was gratifying as showing the extent of business that in all 45,923 tons were shipped, and 4775 tons patent fuel. Condition, Tuesday, firm; inquiry better; Swansea large in good demand, and advance noted; red vein better; rubbly culm satisfactory; duff practically unobtainable; steam little done. Stocks quite a drug. Latest; Best anthracite, 21s. to 23s. net; second, 18s. 6d. to 20s. net; big vein, 16s. to 18s., less 2½; red vein, 11s. 9d. to 13s. 6d., less 2½; machine-made cobbles, 20s. 6d. to 22s. 6d. net; Paris nuts, 22s. to 23s. 6d. net; German nuts, 21s. 6d. to 23s. net; beans, 19s. 6d. to 22s. net; machine-made large peas, 10s. 6d. to 11s. 6d. net; fine peas, 9s. 6d. to 10s. net; rubbly culm, 7s. 6d. to 8s., less 2½; duff, 3s. 6d. to 4s. net. Steam coal: Best large, 18s. 3d. to 19s.; seconds, 14s. 6d. to 15s. 6d.; bunkers, 10s. 6d. to 11s. 6d.; small, 7s. 6d. to 8s. 6d., all less 2½. Bituminous: No. 3 Rhondda, 17s. 6d. to 18s. 6d.; through, 15s. 6d. to 16s.; small, 10s. 9d. to 11s. 6d., all less 2½. Patent fuel, 14s. 6d. to 15s., less 2½.

The Strike of the Cambrian Collieries.

The hopes held out that the strike was coming to an end have been shattered for the time by the decision of the meeting of the South Wales Federation at Cardiff on Monday. This meeting ruled that in view of the statement made by Mr. D. A. Thomas that he did not intimate the terms offered implied a living wage, the whole matter should be again considered by the parent society, and that pending this an appeal should be made for a continuance of the strike fund of £3000 weekly until the difficulty has been cleared up. As this effectually closes the relief, the position is to be considered at a meeting of the executive in Cardiff on Saturday next. The local opinion is that nothing can now be done until the further meeting in London on the 28th of July. The situation is one of great hardship to the trading community, who have trusted the strikers for eight months, and are now being pressed by the wholesale merchants for a settlement of their book debts.

Llanelly.

Collieries have not been very brisk of late, and most of the anthracite mines are only working part time. The local industries are, however, doing well; the sheet works are busy, and ironfounders well employed.

Iron and Steel.

Generally a short week was experienced, and little was done, except at the blast furnaces. Latest market quotations:—Pig iron: Hematite, mixed numbers, 61s. 9d. cash, 62s. month; Middlesbrough, 45s 2d. cash, 46s. 5d. month; Scotch, 52s. 4½d. cash, 52s. 7½d. month; Welsh hematite, 67s. 6d. delivered; East Coast, 66s. to 67s. c.i.f.; West Coast hematite, 66s. to 67s. c.i.f. Steel bars: Siemens, £5; Bessemer, £4 17s. 6d. Rubio ore, 19s. to 19s. 5d. Newport or Cardiff.

Tin-plate.

The latest official announcement is that the market is steady, and general conditions unchanged. Manufacturers complain that orders are not quite so plentiful as they would wish, and at some of the works stocks of plates are accumulating. Bessemer primes and Siemens are quoted at 14s. Other prices as follows:—C.A. roofing sheets, 30 g., £9 to £9 5s.; big sheets for galvanising 30 g., £9 to £9 5s. per ton; finished black plates, £11 10s.; galvanised sheets, 24 g., £10 15s.; block tin, £197 cash, £191 15s. three months. Other quotations:—Copper, £57 5s. cash, £57 17s. 6d. three months; lead, English, £13 17s. 6d; Spanish, £13 7s. 6d.; spelter, £24 12s. 6d.; silver, 24 7.8d. per oz.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

QUIETNESS was the characteristic feature of the iron and steel market last week, makers finding it difficult to obtain fresh orders of weight. For some articles only has an increase in demand been noticed, the lighter industries being better occupied than before. There is no change in pig iron. Scrap iron is wanting in firmness, and shows very little life. Bars are in quiet demand, and the mills are somewhat irregularly occupied. Rates, therefore, show an inclination to weakness, and they have gone down to M. 100 p.t.; exports have been moderate, for after the dissolving of the Convention orders are very keenly competed for. Both dealers and consumers in the wire trade show much reserve. The healthy tone in the building department has caused increasing life in sectional iron and in girders. The wagon-building industry is reported to be in an improving condition; still rates remain depressed, in consequence of the keen and ever increasing competition. Latest quotations are for bars, M. 100 to M. 105; hoops, M. 130 to M. 135; Seigerland and Rhenish-Westphalian steel and iron have advanced to M. 60 to M. 61 for the former, and M. 63 to M. 64 p.t. for the latter.

Coal.

Consumption in engine classes of fuel remains active, and prices are stiff and paying. House coal is as quiet as before.

Austria-Hungary.

The iron and steel market is steady. Regular employment is reported from the mills and factories, both home and foreign orders coming in pretty freely. Structural material is in rising request, in consequence of the good activity in the building trade. Some Government orders have helped to improve the occupation in the railway department. Coal, generally, is in regular demand. In the Ostrau-Karwin district consumption is about equal to production, with the exception of gas coal, which is being put largely into store, the gasworks having reduced their requirements to the utmost during the summer. Prices for all sorts of coal are pretty stiff. Coal for coke making is in better request than previously.

The Iron Market in Belgium.

Discouraging accounts are given regarding iron and steel, the dull tone of previous weeks having become more marked. Pig iron, bars, and semi-finished steel are in slow request, and rates, therefore, show a tendency downwards. On foreign account little is done, German competition being very keen in bars. Wire rods also are neglected, and fluctuating in price; rails and girders continue well inquired for, and so are heavy plates, while sheets show more weakness than previously.

Iron and Steel in France.

Satisfactory employment is generally maintained; in some branches more life has been felt than previously. In the locomotive and wagon building department prospects are very good. The Chemin de fer du Nord is going to increase the number of its wagons, and the Paris-Lyon-Mediterranean Railway has recently ordered 2500 passenger and goods cars, and will soon place a contract for 100 locomotives and tenders. Owing to more life in the iron ore district of Brieg, about 10,000 wagons are to be ordered by the Est Railway, chiefly for carrying ore and coal. Numerous and extensive orders for sleepers, bolts, plates, and switches are being placed, and orders for 40,000 t. steel rails are pending. The demand for girders, sectional iron, and all descriptions of building material is extensive and increasing, and orders in many instances reach far into the first quarter of next year. English and German firms have succeeded in obtaining large orders, inland works being often unable to accept orders for short terms of delivery. Although bars have not been raised in price, they show more stiffness, and less than 160f. p.t. for iron bars and 165f. to 170f. p.t. for steel bars is rarely taken. In the Nord rates are very firm, also in the Est, 170f. to 180f. p.t. being quoted, while in Paris 170f. to 175f. p.t. are generally quoted, special sorts realising 185f. to 190f. p.t. In the Haute Marne 170f. to 185f., or for special sorts 190f., per ton is the price quoted. For girders 190f. to 200f. p.t. is obtained on the Paris market. Increasing firmness is felt in the plate department. The mills report themselves supplied with orders for four or five months. Dealers' prices on the Paris market have been advanced 10f. p.t., 5 mm. plates standing at 205f. p.t.; 3 mm. to 4 mm. plates, 215f.; and 1½ mm. plates, 235f. p.t. The mills in the Nord and Est quote 175f. to 180f. p.t. for sheets; in Paris, 190f. to 195f.; in the Haute Marne, 230f. p.t. is quoted. For heavy plates 180f. p.t. is quoted in the Nord and Meurthe-et-Moselle departments; on the Paris market 205f. is quoted, and in the Haute Marne district 230f. p.t. Crude iron is in a favourable condition both as regards employment and demand; rates, too, are satisfactory. In the Est 72 blast furnaces are working out of 86, which is the same number as last year. The average output per day has, however, risen from 8170 t. to 8815 t. Of the above-named quantity 6245 t. are basic, as compared with 5940 t. last year; foundry pig, 1845 t, in comparison with 1635 t.; forge pig, 720 t., as compared with 595 t. Several blast furnaces are in course of erection in the Haute Marne; there is also talk of six to eight blast furnaces being set to work in the Est, and six in the Nord, to commence in about a year. A large blast furnace works and steel and rolling mills is going to be built by the Ironworks Commentry Tourchambault, and De Cazeville, in Paris, in connection with the mining company Mines de Lens, near Pont à Vendin, in the Pas de Calais district. The works will be quite near the Mines de Lens, which will supply the necessary coal, or rather coke. An output of 300,000 t. of pig iron is contemplated to be consumed by the mills. A good ore mine, owned by the Paris company, is to supply the requirements in iron ore.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, June 21st.

THE old-fashioned revival of iron and steel demand is still in the distance. While a good deal of buying has been done and still is, it is not up to the estimated necessities of the country. It will be recalled that recently the Republic Iron and Steel Company reduced prices on bars. Its June business has doubled, and it has started its long idle Youngstoun, Ohio, plant, which has a capacity of 360,000 tons of steel a year, open hearth. This will run full time until orders are caught up with, while the open-hearth plants around Pittsburg are running half time. The bar mill employers are endeavouring to get their workmen to sign a wages scale for the coming year at a 10 per cent. reduction, and they meet again July 6th to talk it over. The mills will close down July 1st. The steel plate and structural interests are not making any particular effort to get business for future delivery at present prices, but are filling orders for early delivery as they come in. The contracts which have been pending for some time for about 150,000 tons of structural material have not yet been awarded. Much of this material is intended for this city. Plans for subways, the cost of which are, roundly, estimated at some 239,000,000 dols., are being pushed along as fast as the magnitude of such an undertaking permits. There are many conflicting interests to be harmonised. The city needs the facilities, and they will be provided. The water supply problem is being worked out. Plans are laid for 1000ft. piers for ocean liners. We are entering on the dull summer season with only slight assurances of more than the ordinary dragging demand. Yet there are a few high-up men in the steel industry who think they see good reason for a forward movement to take advantage of the present low prices. Crop reports are stimulating. All the wheat and maize lines have braced up for their work of crop transportation. Exports of copper for week, 7269 tons; since June 1st, 15,330 tons. Imports of copper for week, 3680 tons. A fair business has been done for the next three months' deliveries. Asking price for electrolytic, 12⅝ to 12¾. Last week tin broke six cents a pound, and this did not draw out much demand. Total receipts this month, 1404 tons, besides 209 tons yesterday. Domestic buyers are purchasing cautiously, paying very little attention to manipulations here or abroad. Merchantable grades of lead are offered to-day at 4½ spot.

LAUNCHES AND TRIAL TRIPS.

SCREW steamer; built by Northumberland Shipbuilding Company, Limited; to the order of Houlder, Middleton and Co., Limited, and A. Weir and Co., of London; dimensions, 425ft. long; to carry 9000 tons; engines, 28in., 46½in., 78in. by 54in. stroke, pressure 200 lb.; constructed by Earle's Shipbuilding and Engineering Company, Limited; a speed of 13 knots was reached on the trial trip on June 7th.

CLAN MACPHEE, screw steamer; built by Irvine's Shipbuilding and Dry Docks Company; to the order of Clan Line, Limited, Glasgow; dimensions, length 450ft. by 53ft. 6in., depth 37ft.; engines, triple-expansion, 29in., 49in., 80in. by 60in. stroke, pressure 200 lb.; constructed by Richardsons, Westgarth and Co., Limited; trial trip, June 13th; speed, 13½ knots.

ISLEWORTH, steel screw steamer; built by Ropner and Sons, Limited, Stockton-on-Tees; to the order of the Britain Steamship Company, Limited, of London; dimensions, length 403ft., breadth 52ft., and depth 30ft. 3in.; engines, triple-expansion; pressure 180 lb.; constructed by Blair and Co., Limited, Stockton-on-Tees; launch, June 14th.

SALAANHA, screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Bucknall Line; dimensions, 397ft. long by 48ft. 9in. broad; to carry 8720 tons; engines, triple-expansion; constructed by Wallsend Slipway and Engineering Company; launch, June 15th.

SAN ANDRES, steel screw steamer; built by Wood, Skinner and Co., Limited; to the order of Otto Thoresen, of Christiania; engines, triple-expansion, 22in., 36in., 60in. by 39in. stroke, pressure 180 lb.; constructed by North-Eastern Marine Engineering Company, Limited; trial trip, June 15th; speed, 13½ knots.

HARPALYCE, steel screw steamer; built by Wm. Gray and Co., Limited; to the order of J. and C. Harrison, Limited; dimensions, length 441ft., breadth, 53ft. 6in., and depth, 31ft. 8in.; engines, triple-expansion, 28in., 45in., 75in. by 51in. stroke, pressure 180 lb.; constructed by Central Marine Engine Works; trial trip, June 21st.

CATALOGUES.

C. E. HALL, 87, Fargate, Sheffield.—This is a little pamphlet dealing with the "excel all" system of crucible steel melting.

THE SYNCHRONOME COMPANY, 32 and 34, Clerkenwell-road, London, E.C.—A circular on electric time-keeping has reached us.

VICKERS, SONS AND MAXIM, 32, Victoria-street, Westminster, S.W.—A circular sent to us by this firm gives particulars of the "Vicker's" one-lock adjustable reamer.

OZONAIR, Limited, 96, Victoria-street, Westminster, S.W.—Some literature sent to us by this firm deals with apparatus for the commercial production of ozone for all purposes.

"SAVER" CLUTCH COMPANY, Limited, 7, Brazenose-street, Manchester.—An illustrated description of the "Saver" metal-to-metal friction clutch, together with sizes, prices and particulars.

BEYER, PEACOCK AND CO., Limited, Gorton, Manchester.—A pamphlet containing illustrations and descriptions of the chief features of the Garrett locomotive has been sent us by this firm.

PERKIN AND CO., Limited, Junction Engine Works, Whitehall-road, Leeds.—This is a price list of vertical petrol and paraffin engines. A concise general description of these engines is given, also prices and all information of interest to buyers.

RICHARD JOHNSON, CLAPHAM AND MORRIS, Limited, Newton Heath, Manchester.—This firm has issued a new catalogue relating to various kinds of wire guards and woven wire. It has been specially produced for the use of works, as it indicates, amongst other things, approved methods of guarding machinery.

DAVIE AND HORNE, Johnstone, near Glasgow.—Catalogue E has reached us. It has reference to the "Davie" patented simplex pumps for boiler-feeding purposes. The principle of operation of these pumps is clearly explained with the aid of sectional drawings, and prices, dimensions, and other particulars are given.

HOLDEN AND BROOKE, Limited, West Gorton, Manchester.—List No. 211 deals with feed-water heaters constructed on Brooke's high-velocity system, which is based on the theory that heat transmission is dependent on maintaining the greatest possible degree of difference in temperature on the two sides of the heating medium.

GREENWOOD AND BATLEY, Limited, Leeds.—A card to hand from this firm illustrates a new plain manufacturing grinder. It is claimed that with this machine it is impossible to produce tapered ends to the work because the positive feed mechanism operates during the point of reverse and before the traverse of the carriage commences.

THE CONSETT IRON COMPANY, Limited, Consett, Co. Durham.—This company has forwarded its latest booklet giving full particulars respecting its productions. We are informed that programmes and weekly rollings of sections and periodical stock lists are issued by the company, and that copies can be obtained on application.

THE GLOBE ELECTRIC COMPANY, Limited, 11, Farringdon-avenue, E.C.—A pamphlet to hand from this firm gives particulars of arc lamps for photographic purposes. The pamphlet deals with a number of lamps which have been specially designed to meet all drawing-office requirements. A special lamp which has been named the "Photolumen" is described. This is intended for photographic studios, and is claimed to satisfy the demand for a thoroughly reliable and efficient substitute for sunlight.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

JOHN DAVIS AND SON, of All Saints' Works, Derby, have altered their London address to 17, Victoria-street, Westminster.

MR. G. D. MATHEWS, A.M. Inst. C.E., A.M.I.M.E., A.M.I.E.E., has left the Government service at the Royal Arsenal, Woolwich, and has joined the staff of the Tudor Accumulator Company, of 119, Victoria-street, S.W.

MR. A. E. BREWER, for some years works manager for the Railway and General Engineering Company, Limited, Nottingham, has been appointed and has taken up his duties as general manager for John Bellamy, Limited, Millwall.

WE are asked by Heenan and Froude, Limited, Worcester, to state that Mr. R. H. Longbotham, of Wakefield and Doncaster, has taken up the agency for them in Yorkshire, Durham, and Northumberland in connection with all colliery work.

THE Council of the National Electrical Manufacturers' Association have elected Mr. F. H. Nalder to the post of chairman, as, in consequence of Mr. W. H. Butler having for a time severed his connection with the electrical manufacturing industry, he has resigned the chairmanship of the Council.

THE GEARED TURBINE VESSEL VESPASIAN.—In connection with the jubilee celebrations of the Institution of Naval Architects, it has been arranged by the Parsons Marine Steam Turbine Company that the cargo steamship Vespasian, which has been fitted with geared turbines, shall be open to inspection by members of the International Congress who may desire to visit her next week. Tickets of admission will be issued through the Institution of Naval Architects. The vessel will be lying in the West India Docks on Tuesday, Wednesday, Thursday and Friday, and visits can be paid by those who have cards of admission between the hours of 10 a.m. and 6 p.m. Other persons interested in the subject who may desire to inspect the vessel should make application to the Parsons Marine Steam Turbine Company, 8, Victoria-street, London, S.W., or to the Turbinia Works, Wallsend-on Tyne.

CONTRACTS.—The Underfeed Stoker Company has recently received orders for ninety-four stokers of various sizes, these being supplied to electrical undertakings, textile, paper, sewage, match, cocoa, gas, chemical, fish manure, dye, and distilling works, flour mills, poorhouses, &c.—The Great Western, Great Central, Central London, Belgian State, French State, Italian State, Algerian State, and Cape Government Railways, the Cunard Steamship Company, Hon. Corporation of Trinity House, Port of London Authority, River Wear Commissioners, Fishery Board for Scotland, Atlantic Transport Line, Anglo-American Oil Company, Burrell and Sons, and T. and J. Brocklebank, Limited, have recently placed repeat orders for Apexior compound with J. Dampney and Co., Limited, of Cardiff.—Drummond Brothers, Limited, of Ryde's Hill, near Guildford, Surrey, are supplying one of their "Drummond-Barrett" universal machines to the British Admiralty for installation on the repair depôt ship Hecla, now being built. The Admiralty has also expressed its intention of placing similar machines on other depôt ships.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

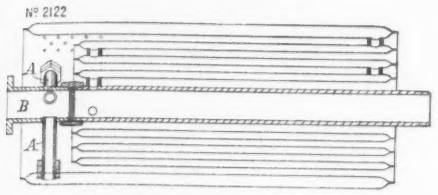
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of the Patent.

INTERNAL COMBUSTION ENGINES.

2122. January 27th, 1911.—IMPROVEMENTS IN EXHAUST SILENCERS FOR INTERNAL COMBUSTION ENGINES, George Arthur Bishop, "Kennythorp," Roundhay-road, Leeds.

The first claim attached to this specification, together with the engraving, will make the nature of this invention quite clear. The claim is as follows:—"A silencer for internal combustion engines comprising a pipe or conduit formed with radial ports, a series of annular chambers constructed entirely of sheet metal and

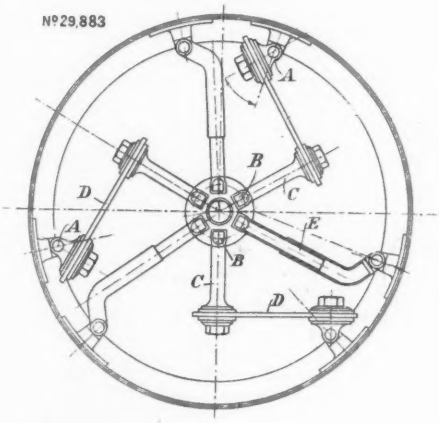


each formed with inlet ports and outlet ports, said chambers being separated by air-cooling spaces that entirely surround the annular chambers, and tubular distance pieces connecting the ports of the pipe to the inlet ports of the first of said annular chambers and connecting the outlet ports of each of such annular chambers except the last one to the inlet ports of the next succeeding chamber." The cooled exhaust gases finally leave the apparatus by way of the conduits A and the orifice B.—*May 31st*, 1911.

MOTOR CARS AND ROAD TRAFFIC.

29,883. December 23rd, 1910. — IMPROVEMENTS IN ELASTIC WHEELS, Giuseppe Ferrando, of Via Montallegro, Villa Gropallo, Genoa, Italy.

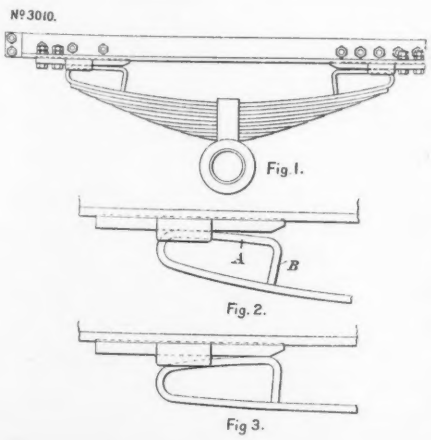
From brackets attached to the inside of the rim blocks A are pivoted and on pins F on the hub, rods C are arranged to oscillate.



The blocks A and the ends of the rods C are joined by plate springs D. In this way the hub is free to rise and fall relatively to the rim. Where the wheel has to transmit a driving effort special telescopic spokes E are provided to take the torsional stresses.—*May 31st*, 1911.

3010. February 6th, 1911.—IMPROVEMENTS IN SPRINGS APPLICABLE FOR USE WITH VEHICLES OR FOR OTHER LIKE PURPOSES, William Ashbee Tritton, James Starkey, and William Foster and Co., Limited, all of Wellington Foundry, Firth-road, Lincoln.

The plate springs described in this patent have a loose bearing and are adapted automatically to change their bearing points and

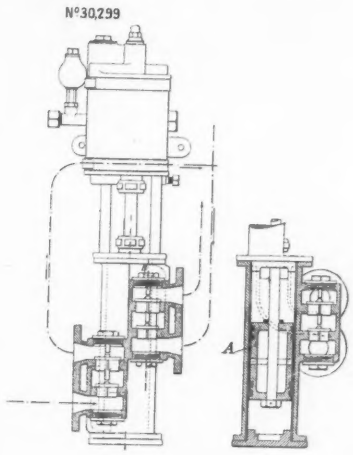


shorten the length of the spring in proportion with the load. The top leaf of the spring is bent over as shown so as to form a slightly curved upper surface A and an abutment B. This bent portion bears against a removable pad attached to the framing, the bearing surface being nominally a cross line in all positions of the spring. As the load increases the line of contact travels towards the axle, that is to say, the effective length of the spring is reduced. Fig. 2 shows the spring with the minimum load and Fig. 3 with the maximum.—*May 31st*, 1911.

LOCOMOTIVES.

30,299. December 30th, 1910.—IMPROVEMENTS IN CONTRIVANCES FOR FEEDING LOCOMOTIVE AND OTHER BOILERS WITH HOT WATER, Charles Caille, of 24, Rue de la Gaité, Le Perreux (Seine), France.

Where a pump is employed to feed boilers it is usual in order to facilitate its working to place it below the level of the reservoir from which it draws its supply. Further, if a feed-water heater is disposed between the reservoir and the pump the heater has to be placed on a level with the reservoir. This invention permits the pump and heater to be placed in any position relatively to one

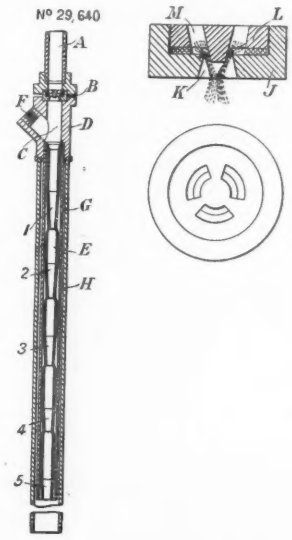


another and to the reservoir. To accomplish this a pump is employed to deliver the cold water from the reservoir into the heater, and a second pump to deliver the heated water into the boiler. In practice the pumps are combined in one machine, and while one is sucking the other is delivering. A common piston A works in the pump barrel, the lower end of which is fed with cold water and the top with hot water. The lower end delivers the cold water into the heater, and the top end delivers the hot water into the boiler. Other details of the invention will be understood from the engraving.—*May 31st*, 1911.

PUMPING AND BLOWING MACHINERY.

29,640. December 21st, 1910.—IMPROVEMENTS IN HYDRAULIC JET SUCTION APPARATUS, William Johnstone Frame, 48, Hamilton-drive, Pollokshields, Glasgow.

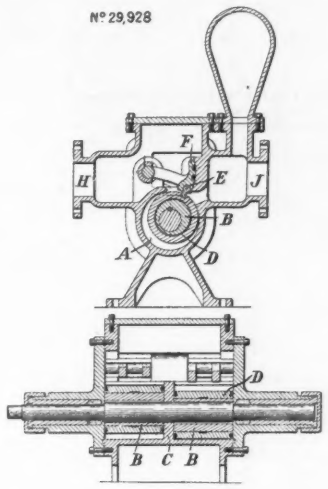
The water under pressure passes from the tube A through the diaphragm B and issues as a jet of spray, which passes across the space C of the suction chamber D into the eduction tube E, which latter has a series of truncated conical contractions marked 1, 2, 3, 4, and 5. F is the suction branch of the suction chamber, G a tube enclosing the eduction tube, and H a tubular protecting



casing. The diaphragm B is composed of a box J having an outlet orifice K with a sharp edge. Screwed into the box is a block L having inclined and converging openings M and a tapered central part which depends into the mouth of the orifice K, so that an annular passage-way is formed round the edge. With this construction of diaphragm the water from the openings M cascades over the edge of the annular opening, forming a hollow annular jet, the particles of which impinge at a point just below the conical centre of the block L. From this point, owing to the reaction, the water breaks up and spreads in the form of finely atomised spray, which travels forward with but very slight diminution of the original velocity of discharge.—*May 31st*, 1911.

29,928. December 23rd, 1910.—IMPROVEMENTS IN ROTARY PUMPS.—Justus Royal Kinney, of Boston, County of Suffolk, Massachusetts, U.S.A.

Within the piston chamber A there is disposed a central shaft carrying two excentrics B, separated by a division wall C. Each excentric is surrounded by an annular piston element D, the ends of which are provided with packing material. The annular pistons are arranged so as always to have one point on their surfaces in contact with the wall of the piston chamber. A dovetailed groove is formed on the upper surface of the pistons, and into this the longitudinal piece E is inserted. The top edge of this piece is rounded off, and fits within a corresponding recess in a blade F. This blade is pivoted so as to oscillate through a small arc. H is the inlet and J the outlet orifice. As the shaft is rotated continuously in one direction, the piston element oscillates back-

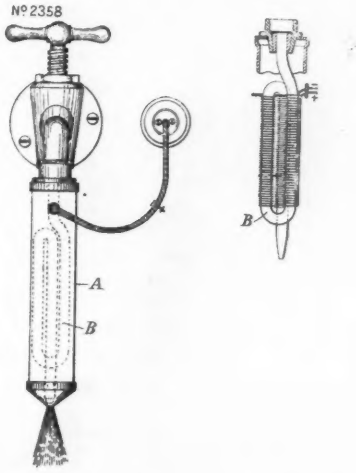


wards and forwards, communicating its oscillatory motion to the blade F. The water or other fluid is caught in the chamber A and compressed in the usual way.—*May 31st*, 1911.

HEATING AND LIGHTING.

2358. January 30th, 1910.—IMPROVEMENTS IN APPARATUS FOR INSTANTANEOUSLY HEATING WATER, Alexandre Trepreau, of 34, Avenue de l'Ile, Joinville-le-Pont (Seine), France.

This specification describes an apparatus for instantly heating water by means of an electric current taken, say, from an ordinary lighting circuit. The engraving shows the invention applied to an ordinary water tap. A metal tube A is attached by a suitable connection to the tap, and is provided with a conical end through

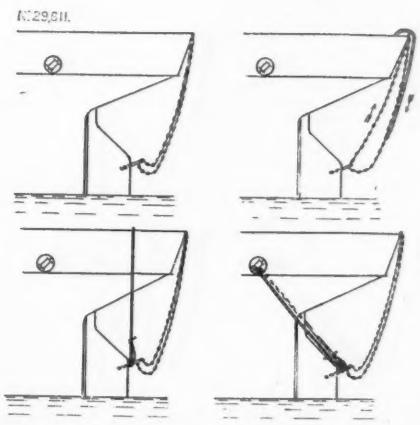


which the water flows. Inside this tube, and delivering just within the conical end, is a glass tube B bent as shown in the separate figure. Round each limb of the glass tube resistance wire is wound, through which electricity flows from a suitable connection on the main lighting circuit. The specification states that with a current of 4 ampères, a temperature of 90 deg. Cent. can be obtained in the water by means of this apparatus. Several modifications are also described and illustrated.—*May 31st*, 1911.

SHIPS AND BOATS.

29,611. December 20th, 1910.—IMPROVED MEANS FOR TEMPORARILY CONNECTING A RUDDER AND STEERING DEVICE, Johan Roland Nilsen, of Strömsgodset, near Drammen, Norway.

By means of the device described in this patent the rudder of a vessel can be connected to the steering apparatus by supplementary cables in case of breakdown. An endless chain passes through an



eye on the rudder, and is attached to the stern plating. To establish the connection a steel wire rope is fixed to the endless

chain and the latter pulled round until the wire rope passes through the eye on the rudder and is brought on deck again. A half-hitch is then made on the rope, and when this has been pulled down to the eye the rope is led over a pulley to the steering apparatus. A similar procedure is employed for the rope on the other side of the vessel.—*May 31st*, 1911.

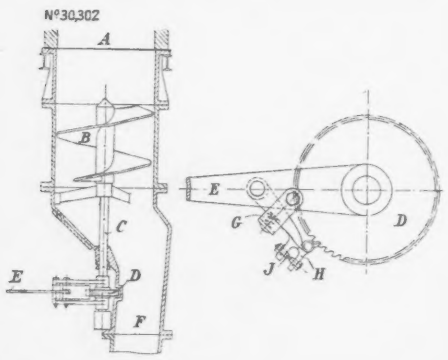
MISCELLANEOUS.

30,091. December 28th, 1910.—IMPROVED MANUFACTURE OF A SUBSTANCE FOR RENDERING CEMENT WATERPROOF, Deutsche Rekord Cement Werke, J. Krümpelmann and Co., and Julius Krümpelmann, all of Lüdinghausen, Westfalen, Germany.

It has already been attempted to render cement waterproof by incorporating tarry or oily substances therewith, but it has been found that the incorporation of such substances is not directly practicable, because in mixing them with wet cement the constituents became separated. This invention consists in using bituminous substances of natural or fossil origin, which are treated in such a manner as to render them capable of emulsifying tarry and oily products, and of being dried to a powder which on being mixed with wet cement again forms an emulsion and has the property of rendering the cement completely waterproof without reducing its strength. One way of carrying out this invention consists in treating bituminous (lias) shale with hydrochloric acid. It is preferred to use shales which contain about 25 per cent. of bitumen, about 15 per cent. of lime, and small quantities (about 2 per cent.) of magnesia, and in which the natural process of carbonification has not reached an advanced stage. The bituminous (lias) shale is finely ground and mixed with crude hydrochloric acid into a paste, which, after the carbonic acid has escaped, is subjected for about three hours to steam of a pressure of about five atmospheres. The mass whilst still hot is then mixed with gas tar, mineral oil or the like, and then dried quickly at a temperature of somewhat about 100 deg. Cent. The bituminous shale, which originally has no water-repelling property whatever, is converted by the treatment with hydrochloric acid into a water-repelling substance which even in the dried state retains the property of forming an emulsion when mixed with wet cement.—*May 31st*, 1911.

30,302. December 30th, 1910.—IMPROVEMENTS IN THE DRIVING GEAR OF APPARATUS FOR DISCHARGING COKE FROM CONTINUOUSLY OPERATED VERTICAL RETORTS, Samuel Glover, "Olivemount," St. Ann's, St. Helens, and John West, "The Firs," Park-road, Southport.

A is the bottom end of a vertical retort from which the carbonised material is extracted; B is the worm extractor which is driven by the shaft C actuated by the ratchet wheel D and pawl hinged to the ratchet pawl of lever E. F is the coke receiving chamber. G is a spring for keeping the ratchet pawl in contact

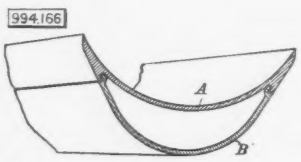


with the teeth of the ratchet wheel. The pawl is constructed with a hinged end H which is bolted in position when in contact with the ratchet wheel by a pin J which is reduced in diameter to allow only sufficient strength to provide for the normal conditions of working, and which will break in the event of the coke chamber F becoming over full and thus cause the part H to become inoperative by releasing it from contact with the ratchet wheel D.—*May 31st*, 1911.

SELECTED AMERICAN PATENTS.

(From the United States Patent-office Official Gazette.)

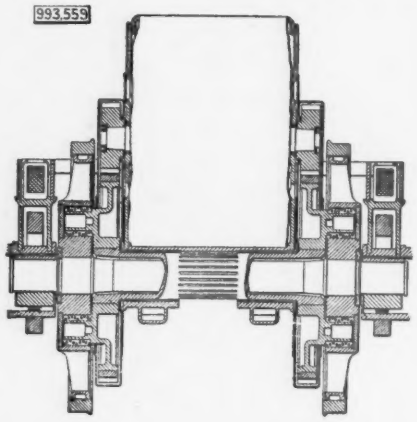
994,166. TURBINE BLADE, *A. Kienast, Leipzig, Germany.—Filed February 17th*, 1911.



This patent is for the construction of turbine blades of sheet metal in the way shown, the portion B being sprung into grooves in A. There are five claims.

993,559. ELECTRICALLY PROPELLED VEHICLE, *R. Siegfried, Pittsburg, Pa., assignor, by mesne assignments, to Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa., a Corporation of Pennsylvania.—Filed April 10th*, 1908. *Renewed March 20th*, 1911.

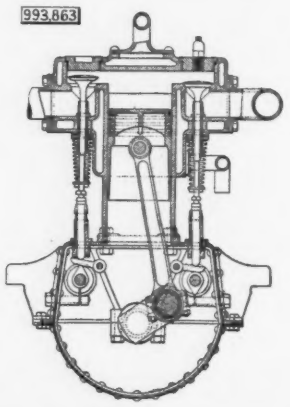
This invention consists in the combination with a pair of truck wheels and their axle, of a pair of gear wheels joined to the truck



wheels and flexibly connected together, and an electric motor having pinions on its armature shaft which mesh with the gear wheels. The small amount of flexibility needed is provided by slotting the "quill" or hollow shaft as shown. There are six claims.

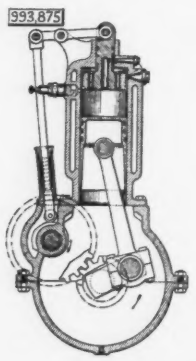
993,863. CRANK CASE CONSTRUCTION FOR GAS ENGINES, *J. T. Moltrup, Beaver Falls, Pa.—Filed April 24th*, 1908.

This patent raises a somewhat interesting question. It is known



that a patent cannot be valid if taken out for a principle. In this instance the patent is really for the use of sheet metal in making the casing for explosive engines. There are five claims.

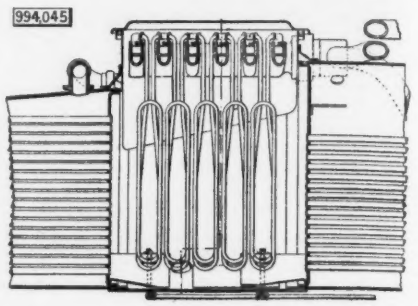
993,875. VALVE MECHANISM FOR INTERNAL COMBUSTION ENGINES, *J. H. Richards, Tamworth, and B. Bellingham, Smethwick, near Birmingham, England.—Filed October 8th*, 1910.



In this engine a ported piston takes the place of poppet valves. There are five long claims.

994,045. STEAM BOILER SUPERHEATER, *Henry H. Vaughan, Montreal, Quebec, Canada, assignor of one-half to Locomotive Superheater Company, New York, N.Y., a Corporation of New Jersey.—Filed October 12th*, 1910.

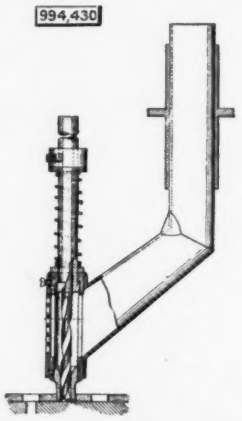
Taken with the drawing the fourth claim adequately describes this invention: "The combination, with a locomotive boiler having an open-topped combustion chamber, of an independent superheater casing which is exterior to the boiler and constitutes the top closure of the combustion chamber, side connections securing said casing to said chamber, a removable cap plate closing said casing, a saturated and a superheated steam header, secured to



opposite sides of said casing, and a plurality of looped or return bend superheating pipes communicating at their ends with said headers and depending in vertical rows in the direct path of the gases through the combustion chamber." There are ten claims.

994,430. BORING TOOL, *C. A. Tunks, Cleveland, Ohio.—Filed March 2nd*, 1911.

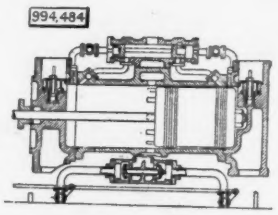
This invention consists in combining an exhaust fan and wind



trunk with the boring tool in the way shown in the drawing. A perforated plate lies over the work as shown to prevent the escape of the borings. There are three claims.

994,484. STEAM ENGINE, *J. Stumpf, Berlin, Germany.—Filed November 16th*, 1910.

This is a further patent for improvements in a uni-directional flow steam engine, with a cylinder having inlet ports at its ends and separate exhaust ports arranged about the centre of the cylinder. A piston is adapted to overrun and control these



exhaust ports at and near the end of its working stroke, a double valve, having oppositely faced valve parts articulated together, a casing in which said valve is mounted and guided, an outlet from said casing, and disposed between the valve parts, connections leading from about the ends of the cylinder to opposite sides of the casing, and cocks in the connections. There are two claims.

THE EXPORT MERCHANT SHIPPERS' GUIDE.—We have received the latest edition of this well-known and valuable annual publication. The issue for 1911 marks the 46th year of publication, and is, as usual, divided up into two volumes, the first of which deals with London, and the second with the provinces. The value of such directories largely depends upon the system of classification adopted in the arrangement of the names. In this respect these volumes leave little to be desired. Given the name and address of any export merchant or manufacturer, it is an easy matter to find out not only his telephone number, telegraphic address, the goods he ships, and the ports to which he sends them, but also the quickest way to reach his office or warehouse. Valuable information as to the Customs tariff of the United Kingdom, and other matters of importance to traders, is also contained in the volumes. The work is published at 15s. 6d. net by the Carter Publishing Company, 32, Dean's-court, Old Bailey, E.C.

END OF VOL. CXI.

Eng. Lit.

GENERAL LIBRARY,
UNIV. OF MICH.
JUL 14 1911

The Engineer.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS AND PUBLICATION, 33, NORFOLK STREET, STRAND, W.C.

VOL. CXI.—No. 2896] LONDON: FRIDAY EVENING, JUNE 30, 1911 [PRICE SIXPENCE

Assistant Engineer Required

for the Public Works Department of Southern Nigeria for two tours each of twelve months' residential service, with possible extension. Age between 25 and 40; preferably unmarried. Strict medical examination and vaccination if necessary.

Salary £300 a year, rising to £400 by annual increments of £20. Free single quarters provided at established stations. Free first-class passage out and home again on satisfactory termination of engagement; half salary on voyage out; full salary from date of arrival in the Colony. Two months' leave on full pay after twelve months' tour, increased to four months if returning to the Colony, with full pay during voyage or voyages and free passages.

Candidates should have served their articles with a member or an associate member of the Institute of Civil Engineers or be possessed of a diploma from some recognised Engineers' College, or have been engaged since completion of their articles on public works in a British Colony. They should be capable of designing and carrying out buildings, bridges, and other structures, of taking out priced bills of quantities and preparing detailed estimates, and should have a knowledge of book-keeping and accounting. They should be competent to execute surveys and take sections and lay out and construct roads, and be familiar with the use of surveying instruments, including theodolite, the dumpy level, the prismatic compass, and the box sextant. They should have some knowledge of dock and harbour work and of sanitary and water engineering. Preference will be given to candidates who have served their articles with a municipal or county engineer, or who have been or are attached to the Special Reserve, Royal Engineers, and have since completing their articles had experience abroad, preferably in a British Colony. Candidates must be of British parentage.

Application by letter (no special form required), stating age, whether married or single, giving full particulars of experience, accompanied by copies of testimonials (not originals), with names and addresses of referees of whom inquiries can be made as to capabilities and character, should be sent at once to the CROWN AGENTS for the Colonies, Whitehall-gardens, London, S.W.

Quote M. 4804 on left-hand top corner of application.

This advertisement contains all the information available concerning the appointment. 885

Assistant Locomotive

SUPERINTENDENT REQUIRED for the Baro Kano Railway in Northern Nigeria, for two tours each of twelve months' residential service, with possible extension. Age between 28 and 40, preferably unmarried. Strict medical examination and vaccination if necessary.

Salary £350 a year, rising to £400 by annual increments of £15. Free single quarters provided at established stations. Free first-class passage out and home again on satisfactory termination of engagement. Half salary on voyage out; full salary from date of arrival in the Protectorate. Two months' leave on full pay after twelve months' tour, increased to four months if returning to the Protectorate, with full pay during voyage or voyages and free passages.

Candidates must have had a thorough general training in the shops of one of the leading railways in this country, and have had experience in firing. Preference will be given to a man who has had charge of a district and running shed, had good shop and running experience, and is well up in the routine work of a railway office. Candidates must have had a good theoretical as well as practical training.

Application by letter (no special form required), stating age, whether married or single, giving full particulars of experience, accompanied by copies of testimonials (not originals), with names and addresses of referees of whom enquiries can be made as to capabilities and character, should be sent as soon as possible to the CROWN AGENTS for the COLONIES, Whitehall-gardens, London, S.W.

Quote M4849 on left-hand top corner of application.

This advertisement contains all the information available concerning the appointment. 923

Re Ralph Elliott, deceased.

Pursuant to an Order of the

High Court of Justice, Chancery Division, made in the matter of the estate of Ralph Elliott, deceased, and in an action, Lord (trading as "Fox, Head and Co.") against Elliott, 1911, E. 497, the CREDITORS of Ralph Elliott, late of Middlesbrough, in the County of York, engineer and boilermaker, who died on the 7th day of August, 1909, are on or before the 31st day of July, 1911, to SEND by post, prepaid to Mr. J. W. R. Punch, as member of the firm of J. W. R. Punch and Robson, of 35, Albert-road, Middlesbrough, aforesaid, the solicitors of the plaintiff, a creditor of the said deceased, their CHRISTIAN and SURNAMES, ADDRESSES and DESCRIPTIONS, the full particulars of their CLAIMS, a STATEMENT of their ACCOUNTS, and the nature of the SECURITIES (if any) held by them, or in default thereof they will be peremptorily excluded from the benefit of the said Order.

Every creditor holding any security is to produce the same before Mr. Justice Eve at his Chambers, the Royal Courts of Justice, London, on Friday, the 13th day of October, 1911, at 12.30 o'clock in the afternoon, being the time appointed for adjudication on the claims.

Dated this 27th day of June, 1911.

ILIFFE, HENLEY & SWEET,
2, Bedford-row, London, W.C.,
Agents for J. W. R. Punch and Robson, Middlesbrough,
898 Plaintiff's Solicitors.

City and Guilds Technical COLLEGE, FINSBURY.

(LEONARD-STREET, CITY-ROAD).

A COLLEGE FOR THE SCIENTIFIC TRAINING OF STUDENTS who are preparing to become ELECTRICAL OR MECHANICAL ENGINEERS OR CHEMISTS,

and for ENGINEERING PUPILS who desire to supplement their practical training by a TWO YEARS' COURSE of INSTRUCTION in the PRINCIPLES of ENGINEERING SCIENCE.

The instruction is mainly given in the various laboratories, most of which have been recently re-equipped.

The College does not prepare students to pass external examinations.

A Certificate of proficiency is awarded by the Institute to students who complete a satisfactory course of instruction.

The subjects of the Entrance Examination are Mathematics and English; but the Matriculation of any British University is accepted instead.

The Courses in Mechanical and Electrical Engineering cover a period of two years, and those in Chemistry three years. There are arrangements also for three-year courses in Engineering for those who desire. Fees, £20 per annum.

ELECTRICAL ENGINEERING AND PHYSICS—
PROFESSOR SILVANUS P. THOMPSON, D.Sc., F.R.S.
(Principal of the College).

MECHANICAL ENGINEERING AND MATHEMATICS—
PROFESSOR E. G. COKER, M.A., D.Sc., M. Inst. M.E.

CHEMISTRY—
PROFESSOR RAPHAEL MELDOLA, D.Sc., F.R.S., F.I.C.

City and Guilds of London Institute,
Gresham College,
Basinghall-street, E.C. 706

University College, Nottingham.

The Council invite APPLICATIONS for the PROFESSORSHIP of MINING. Salary £400.

The Professor appointed will be required to commence work on September 18th.

Further particulars and forms of application may be obtained from the REGISTRAR, to whom applications must be sent not later than July 17th. 892

City of Coventry.—Extension of Baginton Sewage Farm.

CONTRACT No. 2.

The Corporation of the City of Coventry invite TENDERS for the SUPPLY and DELIVERY of the necessary 24in., 20in., 18in., 15in., 12in., and 9in. CAST IRON PIPES, including bends, junctions, special lengths, &c., together with VALVES, &c., required in connection with the Extension of the Baginton Sewage Farm.

General conditions, specification, form of Tender, and schedule of prices may be obtained after payment of Two Guineas has been made to the City Treasurer (which will be returned on receipt of a bonâ fide Tender), on application to the undersigned, St. Mary's Hall, Coventry.

Sealed Tenders, endorsed "Tender for Cast Iron Pipes, &c., Baginton Sewage Farm," to be delivered to the Town Clerk's Office, 10, Hay-lane, Coventry, not later than 5 p.m. on Monday, the 10th July, 1911.

The lowest or any Tender will not necessarily be accepted, and the Corporation reserve the right to accept the whole or any part of any Tender. No Tender will be considered which is not made out on the form supplied.

J. E. SWINDLEHURST, M. Inst. C.E.,
City Engineer and Surveyor.

Saint Mary's Hall,
June 21st, 1911. 858

City of Nottingham. — Water Department

DERWENT VALLEY WATER SUPPLY.
PIPE LAYING.

The Water Committee invite TENDERS for LAYING and JOINTING about 4880 yards of 24in. PIPES, 8080 yards of 16in. PIPES, and 270 yards of 15in. PIPES, in connection with the Derwent Valley Supply.

The Contract Works will extend from the Great Northern Railway Bridge near Langley Mill to a point near Watnall Hall, and from Papplewick Reservoir to the junction of Lime-lane with the Oxton-road, and will include the fixing of valves and ironwork, and other appurtenant work in connection with the line of pipes.

Plans and drawings may be seen, and printed specification, schedule, and form of Tender may be obtained on application to Mr. F. W. Davies, Water Engineer, St. Peter's Church Side, Nottingham, accompanied by a cheque for £5, which will be refunded on receipt of a bonâ fide Tender and the return of all the documents.

Sealed Tenders, endorsed "Tender for Pipe Laying, Derwent Valley Supply," and addressed to the undersigned at the Guildhall, Nottingham, to be delivered not later than noon on Monday, the 10th day of July, 1911.

The Committee do not bind themselves to accept the lowest or any Tender.

By order,
J. A. H. GREEN,
Guildhall, Nottingham, Town Clerk.
20th June, 1911. 849

CONTRACTS.

Great Southern and Western Railway (Ireland).

The Directors of the Great Southern and Western Railway Company are prepared to receive TENDERS for the SUPPLY of the undermentioned MATERIAL for the year from 1st August, 1911, to 31st July, 1912:—

	No. of Form.
MATERIALS FOR ROLLING STOCK CONSTRUCTION.	
Axles, 1 oco. Crank	101
Do. Do. Straight	102
Do. Carriage and Wagon	103
Tyres, Locs.	104
Do. Carriage and Wagon	105
Spring Steel Bars	106
Springs, Volute	107
Steel Castings	110
Copper Plates	111
Do. Rods or Bars	112
Brass Tubes for Boilers	114
Brass and Copper Sheet, Tube and Wire	115
Steel Plates for Boilers	116
Steel Rivets for Boilers	116a
Wheel Centres, Wrot. Iron	119
Iron Plates and Rivets, Best Yorkshire and Cable Bars	120
Iron Bars, Plain and Sectional Ordinary	121
Iron Plates and Sheets, Plain and Sectional Ordinary	122
Steel Plates and Sheets, Plain and Sectional Ordinary	123
Steel Ferrules for Boiler Tubes	124
VACUUM BRAKE MATERIAL.	
India Rubber Diaphragms	125
Do. Sleeves or Miniature Sacks	126
Do. Connecting Hose	127
Do. Rolling Rings, &c.	128

	No. of Form.
OTHER MATERIAL.	
Calcium Carbide	136
Carbons for Electric Light	137
Cotters, Flat, Spit	138
Disinfectant Fluid	139
Fence Stakes	140
Handles	141
Point Rodding, Channel	143
Pins, Taper, Split	144
Saws	145
Steel, High Speed for Tools	146
Twist Drills, High Speed	147
OILS.	
Blended Rape for Lamps	155
Pure Rape for Cobra	156
Mineral for Lamps and Oil Gas and Cleaning	157
Do. Do. Lubricating	158
COALS.	
Gas	
House	
Splint	
Coke, Foundry	
FOR HALF-YEAR FROM 1st AUG., 1911, TO 31st JAN., 1912.	
Lead, &c., White and Red Leads	161
Linseed Oil	162
Tallow and Palm Oil	163

Forms of Tender can be obtained, on payment of 6d. each, from the Company's Storekeeper, at the General Stores, Inchicore, Dublin, to whom inquiries for information should be made direct.

The Tenders to be sent in, endorsed "Tender for Stores," and addressed to the undersigned, so as to be with him before 10 o'clock a.m. on Wednesday, the 5th July, 1911.

The Directors will not consider any Tender except those furnished on the Company's forms, and do not bind themselves to accept the lowest or any Tender.

By order,
R. CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin, June, 1911. 768

Ipswich Corporation Waterworks.

TO WELL SINKERS AND CONTRACTORS.

The Ipswich Corporation Waterworks Committee hereby invite TENDERS for SINKING a 10ft. diameter CAST IRON LINED WELL, to a depth of about 80ft. into the Upper Chalk.

The site of the well may be inspected by appointment with the undersigned, from whom plans, copies of the specification, form of Tender, and schedule of prices may be obtained on receipt of One Guinea, returnable on condition that a bonâ fide Tender is sent in.

Sealed Tenders must be delivered at the Town Hall, Ipswich, addressed to the Waterworks Committee, and endorsed "Tender for Well," before Twelve o'clock noon on Thursday, the 27th day of July, 1911.

The Committee do not bind themselves to accept the lowest or any Tender, and no allowance whatever will be made for any expenses incurred in the preparation of any Tender.

By order of the Committee,
C. W. S. OLDHAM,
Engineer,
Ipswich Corporation Waterworks.

Waterworks Offices, Ipswich,
June, 1911. 917

Metropolitan Borough of Poplar.

—The Council of the Metropolitan Borough of Poplar are prepared to receive TENDERS for the SUPPLY, DELIVERY, and ERECTION complete, on foundations to be prepared by them at their Electricity Works, Glaucus-street, Bromley-by-Bow, London, E., of the following plant:—

(1) OVERHEAD COAL BUNKER.
(2) COAL CONVEYOR.
(3) EXTENSION AND MODIFICATION TO EXISTING COAL CONVEYOR.

Specification and form of Tender may be obtained from Mr. J. Horace Bowden, Borough Electrical Engineer and Manager, Glaucus-street, Bromley-by-Bow, London, E., on payment of 5s., which will not be returned.

Sealed Tenders, addressed to the Town Clerk, Council Offices, High-street, Poplar, London, E., endorsed "Tender for Overhead Bunker and Coal Handling Plant," are to be delivered by 10 a.m. on Saturday, July 15th, 1911.

The Council do not bind themselves to accept the lowest or any Tender.

LEONARD POTTS,
Town Clerk
921

Otago Harbour Board. — Tug and Salvage Steamer.

The Otago Harbour Board, Dunedin, New Zealand, invites TENDERS for the CONSTRUCTION and DELIVERY of a STEEL TWIN-SCREW TUG and SALVAGE STEAMER.

Plans and specifications can be inspected at the Offices of the High Commissioner for New Zealand, London, the Mersey Dock and Harbour Board, and the Clyde Navigation Trustees.

Persons desiring to submit Tenders may obtain copies of the plans, specifications, and conditions from the High Commissioner for the Dominion of New Zealand on application, upon payment of the sum of £10 for plans and specifications, and 10s. 6d. for specifications alone. Such sum will be returned to bonâ fide tenderers after receipt of a Tender accompanied by the prescribed documents and drawings.

Tenders, enclosed in a sealed envelope, endorsed "Tender for Tug and Salvage Steamer," and addressed to the undersigned, will be received up till Wednesday, the 6th September, 1911.

J. BLAIR MASON,
Secretary and Engineer.

Harbour Offices, Dunedin,
Dominion of New Zealand. 298

Parish of St. Giles, Camberwell.

TENDER FOR DRYING HORSES, &c.

The Guardians of the Poor of the Parish of St. Giles, Camberwell, will at their meeting to be held on the 12th July, 1911, be prepared to receive TENDERS for the SUPPLY and FITTING-UP of SIXTEEN DRYING HORSES, and ONE 36in. HYDRO EXTRACTOR in the Laundry at their Workhouse, Gordon-road, Peckham, S.E.

Forms of Tender can be had upon application at these Offices, and the same must, when duly completed, be returned here, marked "Tender for Drying Horses, &c.," not later than Six o'clock p.m., on the above-mentioned date. Further particulars can be obtained from the Engineer, at the Infirmary, Brunswick-square, Camberwell, between the hours of 10 a.m. and 12 Noon.

Canvassing the Guardians in respect of this Tender will be deemed a disqualification.

CHARLES S. STEVENS,
Clerk to the Guardians.

Guardian's Offices,
29, Peckham-road, S.E.
28th June, 1911. 924

Reigate Rural District Council.—

The above Council having to remove pump, &c., at its Horley Sewage Works, has for SALE by TENDER about TEN TONS of IRON, consisting of Pulleys, Shafting, &c., in good condition.

The above can be viewed at any time; particulars to be obtained and Tenders delivered to Mr. Nimrod Walter, the Council's Surveyor, South Park, Reigate, marked "Tender for Iron," not later than July 3rd, 1911.

FRANK C. MORRISON,
Clerk.
19th June, 1911. 864

The Bengal and North-Western Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY and DELIVERY of—

(I.) DOG SPIKES.
(II.) COPPER, TIN, and ZINC INGOTS.
(III.) RED and WHITE LEAD,

as per specifications to be seen at the Company's offices.

Tenders, addressed to the undersigned, and marked "Tenders for Dog Spikes," or as the case may be, are to be lodged not later than noon on Tuesday, the 11th day of July, 1911.

For each specification a fee of 10s. will be charged, which cannot under any circumstances be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
ALEXANDER IZAT,
Managing Director.

237, Gresham House,
Old Broad-street, London, E.C.,
28th June, 1911. 936

The Calcutta Electric Supply Corporation, Limited.

COSSIPORE HIGH-TENSION SCHEME.

The above Corporation are prepared to receive TENDERS for the SUPPLY, DELIVERY, and ERECTION at the site of their Cossipore Station, Calcutta, of the following:—

Specification No. 16.—AUXILIARY PLANT and PIPE-WORK.

Copies of this specification, along with drawings and general conditions, can be obtained on and after Monday, the 3rd July, from the undersigned, on payment of a fee of Two Guineas, which will be returned on receipt of a bonâ fide Tender, or on the return of all the documents with a satisfactory explanation as to the contractor's inability to tender.

Tenders, which are to be written on the forms at the end of the specification, must be enclosed in sealed envelopes, endorsed on the outside "Electric Plant, Tender to Specification 16," and sent to the Secretary of the Calcutta Electric Supply Corporation, Limited, Salisbury House, London-wall, E.C., so that they can be received by him before 10 o'clock on the 24th July.

The Corporation do not bind themselves to accept the lowest or any Tender, and no allowances whatever will be made for expenses incurred in the preparation of a Tender.

The specification and drawings can be seen at the office of Messrs. Kennedy and Jenkin, No. 17, Victoria-street, S.W., but can only be obtained from the undersigned.

FRANCIS R. REEVES, Secretary,
The Calcutta Electric Supply Corporation, Limited,
Salisbury House, London-wall, E.C.
27th June, 1911. 876

The Great Indian Peninsula Railway Company.

The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely:—

Ropes, Twines, &c.	Turpentine.
Grindstones.	Signal Wire Fittings.
Locks, &c.	Fencing Materials.
Metals.	Screw Couplings.

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.

Tenders must be delivered in sealed envelopes, addressed to the undersigned, marked "Tender for Ropes, Twines, &c.," or as the case may be, not later than 11 o'clock a.m. on Thursday, the 6th July, 1911.

The Directors do not bind themselves to accept the lowest or any Tender.

J. I. BERRY,
Secretary.

Company's Offices,
48, Copthall-avenue, E.C.,
London, 28th June, 1911. 901

Twickenham Urban District Council.

OLD MACHINERY AND PLANT, SEWAGE DISPOSAL WORKS.

The above Council hereby invite TENDERS for the PURCHASE of OLD MACHINERY and PLANT at the SEWAGE DISPOSAL WORKS, Mereway, Twickenham, consisting of two sets of single-cylinder horizontal condensing pumping engines, one single-cylinder horizontal condensing direct-acting steam pump, two Lancashire boilers, and a quantity of old steam pipes and fittings.

Further particulars can be obtained on application at the office of Mr. Fred W. Pearce, F.S.I., Surveyor to the Council, Town Hall, Twickenham.

Sealed Tenders, endorsed "Tender for Old Machinery and Plant," to be delivered to the undersigned not later than noon on Wednesday, the 12th day of July, 1911.

The Council do not bind themselves to accept the highest or any Tender.

By order,
H. JASON SAUNDERS,
Clerk to the Council.

Town Hall, Twickenham,
27th June, 1911. 929

Gas Engineer Required, Experienced

in Gas Producer Plants, capable of starting up and supervising the running of mechanical producers.—Address, 863, Engineer Office, 33, Norfolk-street, Strand, W.C. 863 A

TO CONTRACTORS, QUARRY OWNERS, AND OTHERS

The Wrexham and East Denbigh-shire Water Company

have for SALE ONE LIGHT LOCOMOTIVE, 2ft. gauge, in first-class running order, fully insured; also about One Mile of LINE, steel rails, 20 lb. to the yard, with pressed steel sleepers.

All purchased new in 1903 for construction of reservoir.

Apply, ENGINEER, Water Company, Wrexham. 419

Borough of Brackley.—Wanted,

a competent WORKING FITTER and ENGINE DRIVER, to take charge of a pair of Horizontal Pumping Engines and a Suction Gas Plant working deep well pumps at the Corporation Waterworks. Commencing salary 35s. a week.

For full particulars apply—

C. E. BARNES,
Town Clerk.
Brackley, Northants. 887

Wanted, for a Large Ironworks

in Lancashire, a thoroughly competent BOILER INSPECTOR, capable of taking charge of, and to be responsible for, the efficient working of about 100 boilers, including Lancashire, Cornish, puddling furnace, travelling crane, and locomotive boilers. Must have been a practical working boilermaker, able to give first-class references as to character and capabilities.—State salary required and when at liberty to 889, Engineer Office, 33, Norfolk-street, Strand, W.C. 889 A

Wanted, Qualified Chief Engineer

in a LONDON BREWERY. Must have experience with Electric, Steam, Gas-producing, and Freezing Plant, &c.—State age, experience, and salary required, to A. B., care of Hooper and Batty, 15, Walbrook, E.C. 886 A

Wanted, Smart, Energetic, and

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and practical ENGINEER to TAKE CHARGE of engineers, electricians, and coppersmiths in large manufacturing establishment. Experience of steam and suction gas plants, and sound knowledge of electricity essential.—Address, stating salary required and giving particulars of experience, 871, Engineer Office, 33, Norfolk-street, Strand, W.C. 871 A

Wanted, Works Manager for

Motor Works employing 1000 hands. Applications will only be considered from trained technical men who hold, or have held, a similar or Assistant Works Manager's position in a first-class motor works. Salary offered £500 per year.—Write, stating age, and full particulars of experience, to Box 5915, Willing's, 125, Strand, W.C. 881 B

Wanted, Young Engineer. Must

be able to level and set out small line of railway.—Address, stating age, and salary required, and all particulars, to 888, Engineer Office, 33, Norfolk-street, Strand, W.C. 888 A

Assistant Engineer Required for

London Establishment; must be well acquainted with Working of Boilers, High-speed Engines, Electrical Plant, Water-softening Apparatus, and Pumping Machinery.—State full particulars and salary required to Box 6364, care of Pool's Advertising Offices, Fleet-street, E.C. 933 A

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Wanted, Assistant Draughtsman for Willesden District,

used to general and motor engineering.—State age, salary required and experience to P997, Engineer Office, 33, Norfolk-street, Strand, W.C. P997 A

Wanted, Draughtsman to Design

Jigs and Tools for manufacture of small intricate machines, must be thoroughly up-to-date; permanency.—Reply, stating full particulars, to 868, Engineer Office, 33, Norfolk-street, Strand, W.C. 868 A

Wanted, Draughtsman Used to

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Engineer's Office in the neighbourhood of Manchester, an ASSISTANT JUNIOR DRAUGHTSMAN; quick and accurate surveyor, accustomed to use of theodolite and level. Salary £50 per annum.—Address, 856, Engineer Office, 33, Norfolk-street, Strand, W.C. 856 A

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SITUATIONS, FOR SALE, &c.

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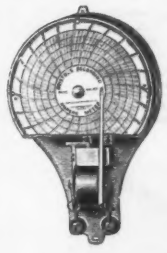

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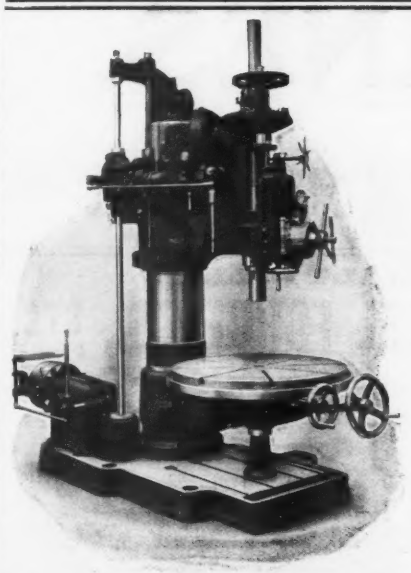

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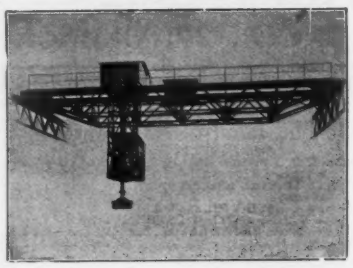

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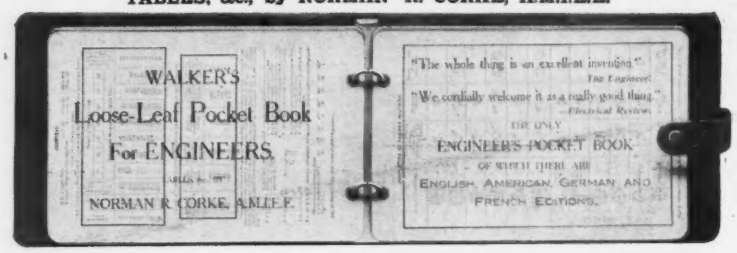

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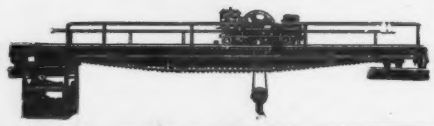

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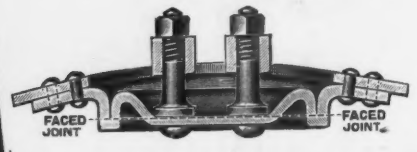

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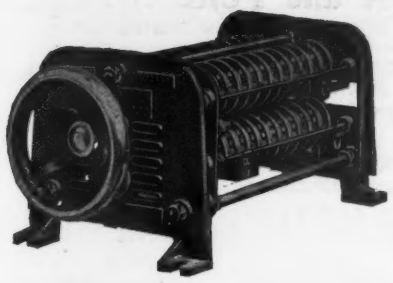

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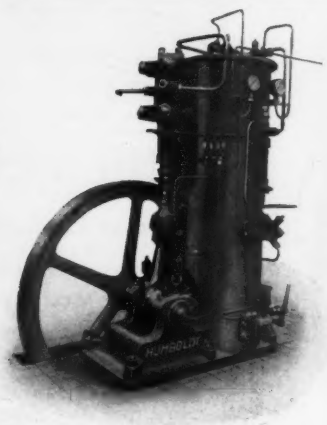

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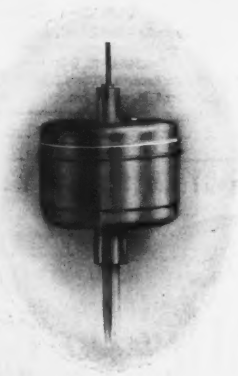

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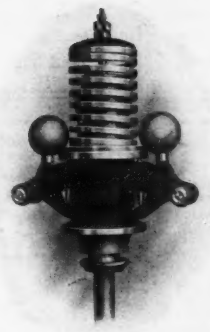

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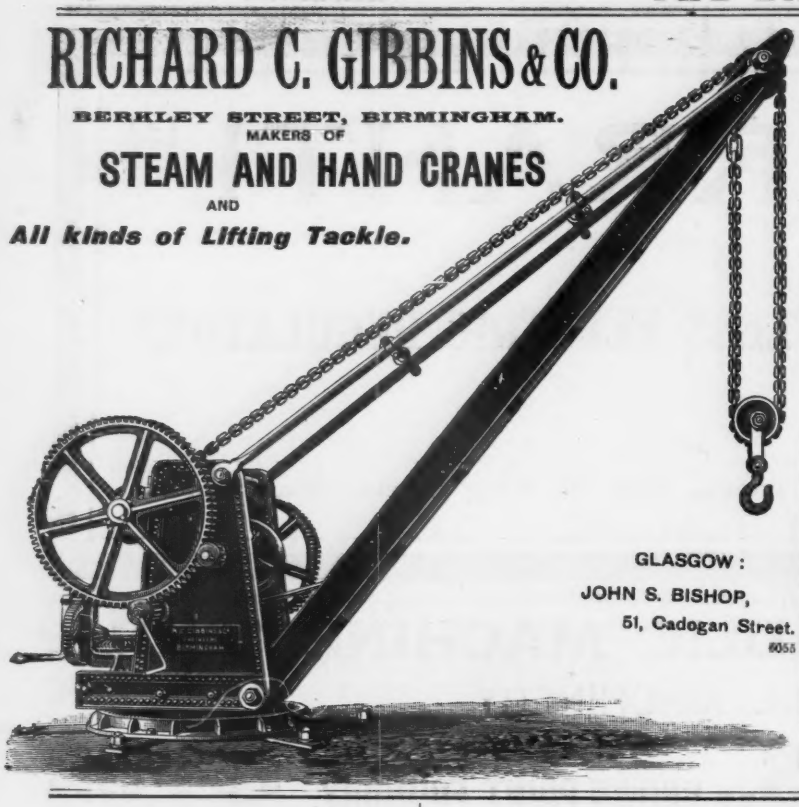

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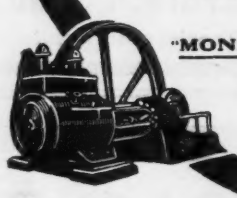

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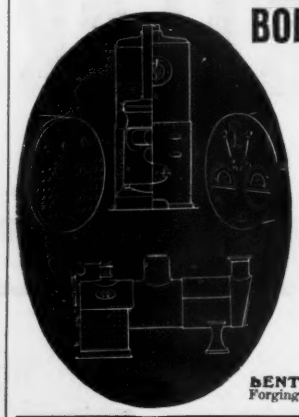

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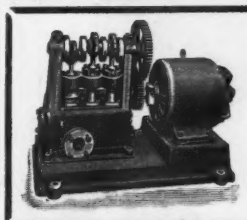

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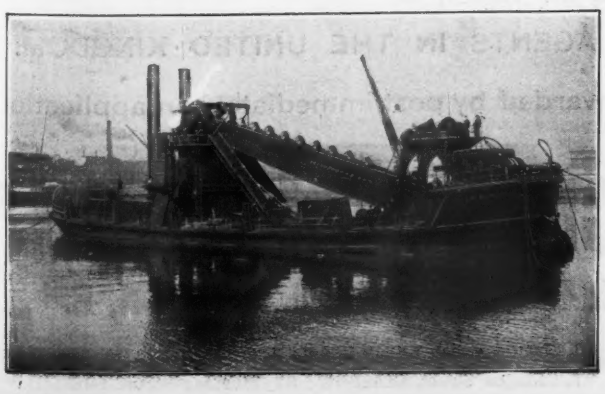

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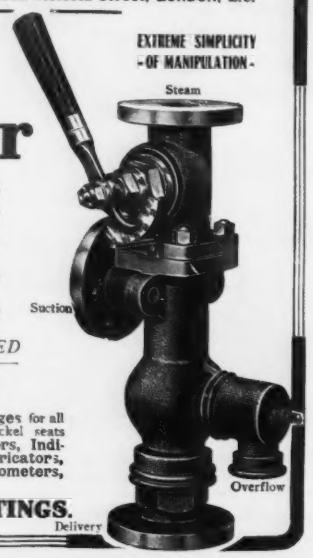

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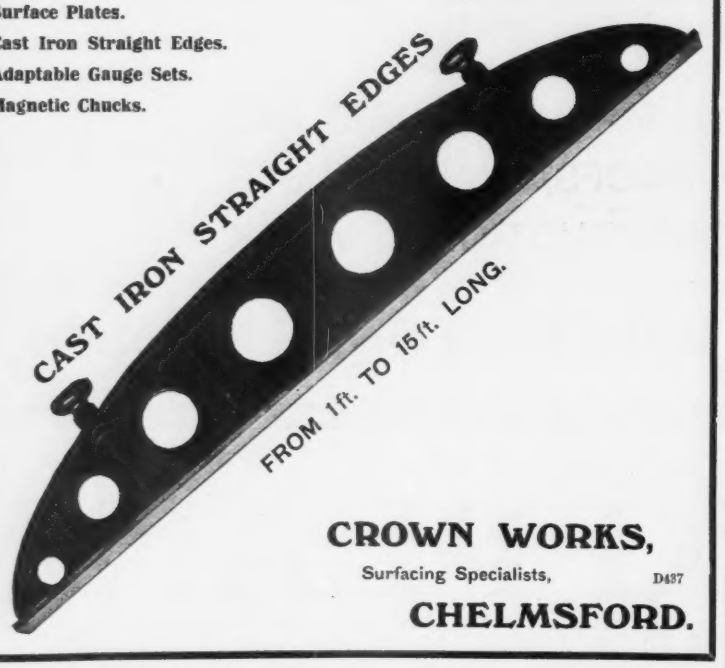

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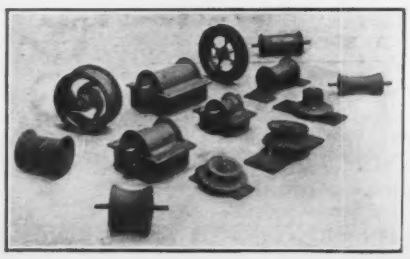

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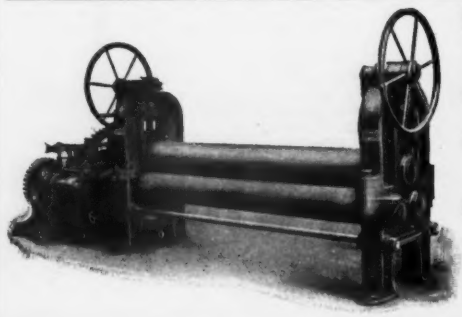

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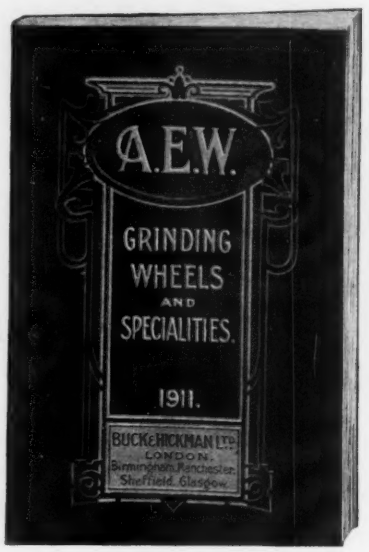

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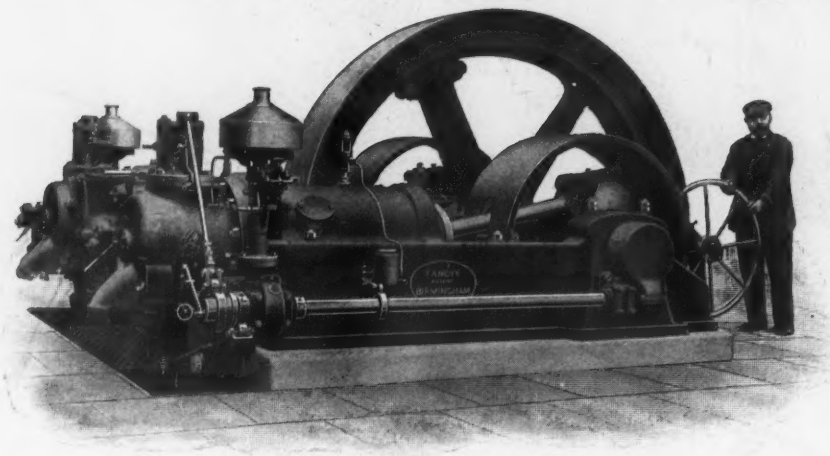

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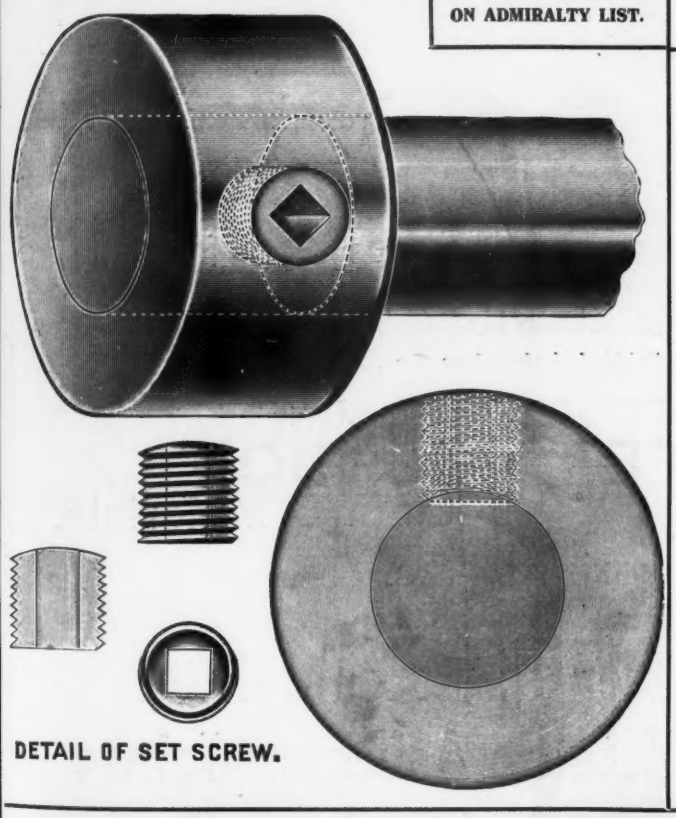

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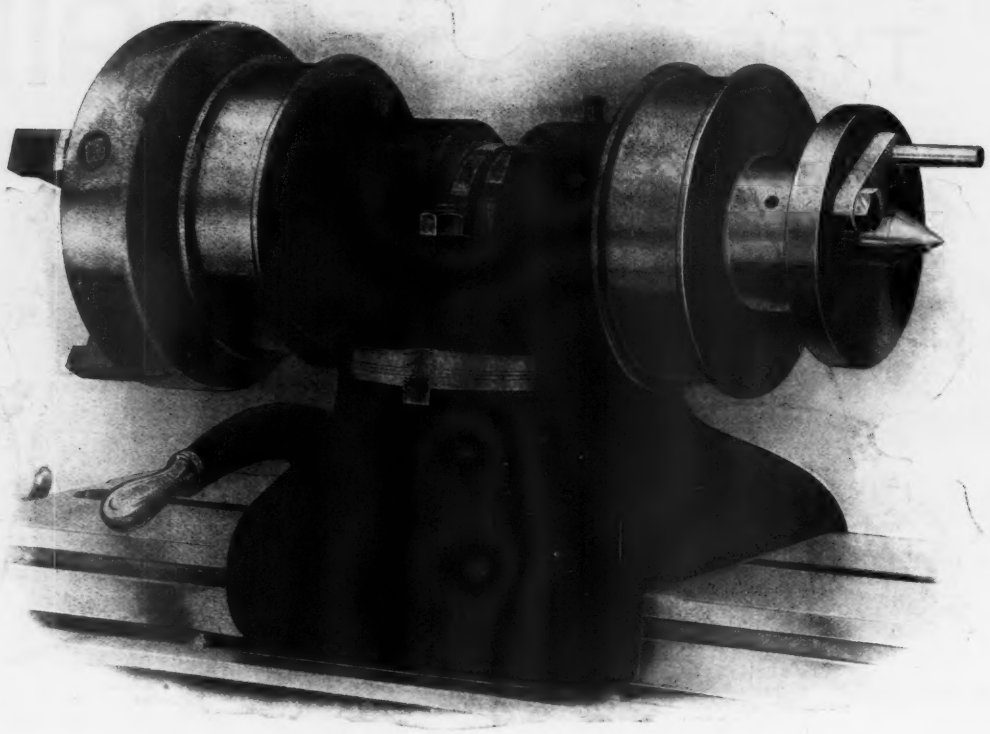

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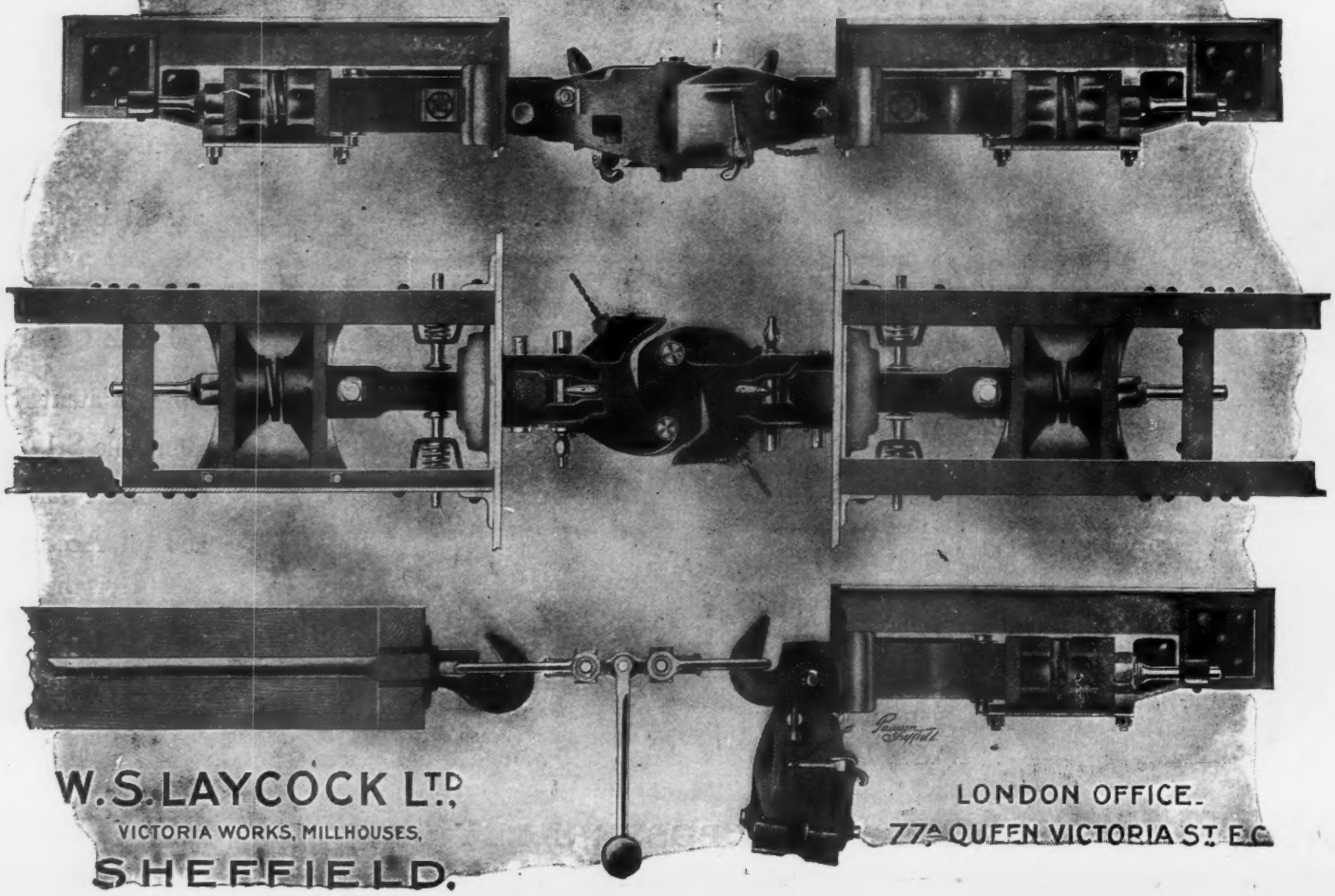

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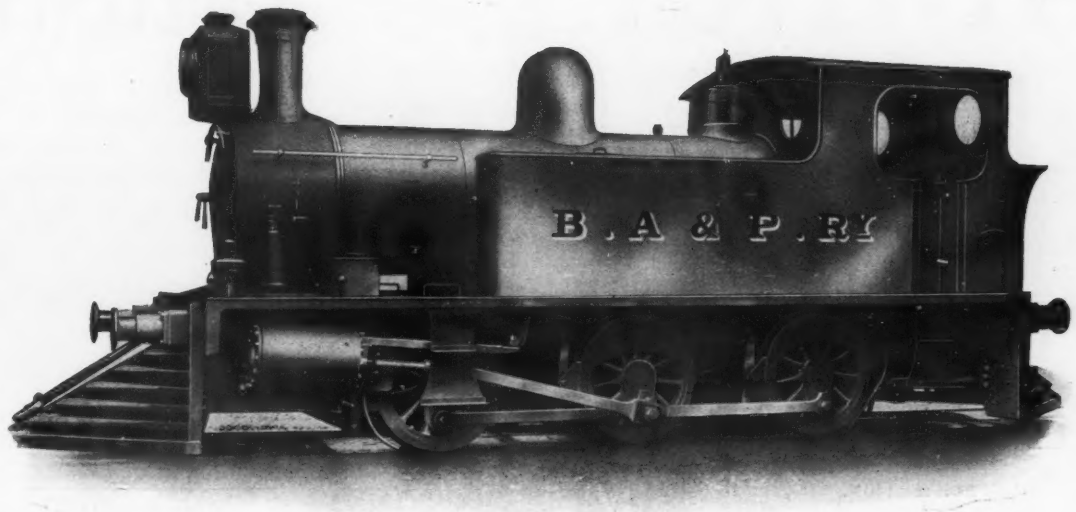

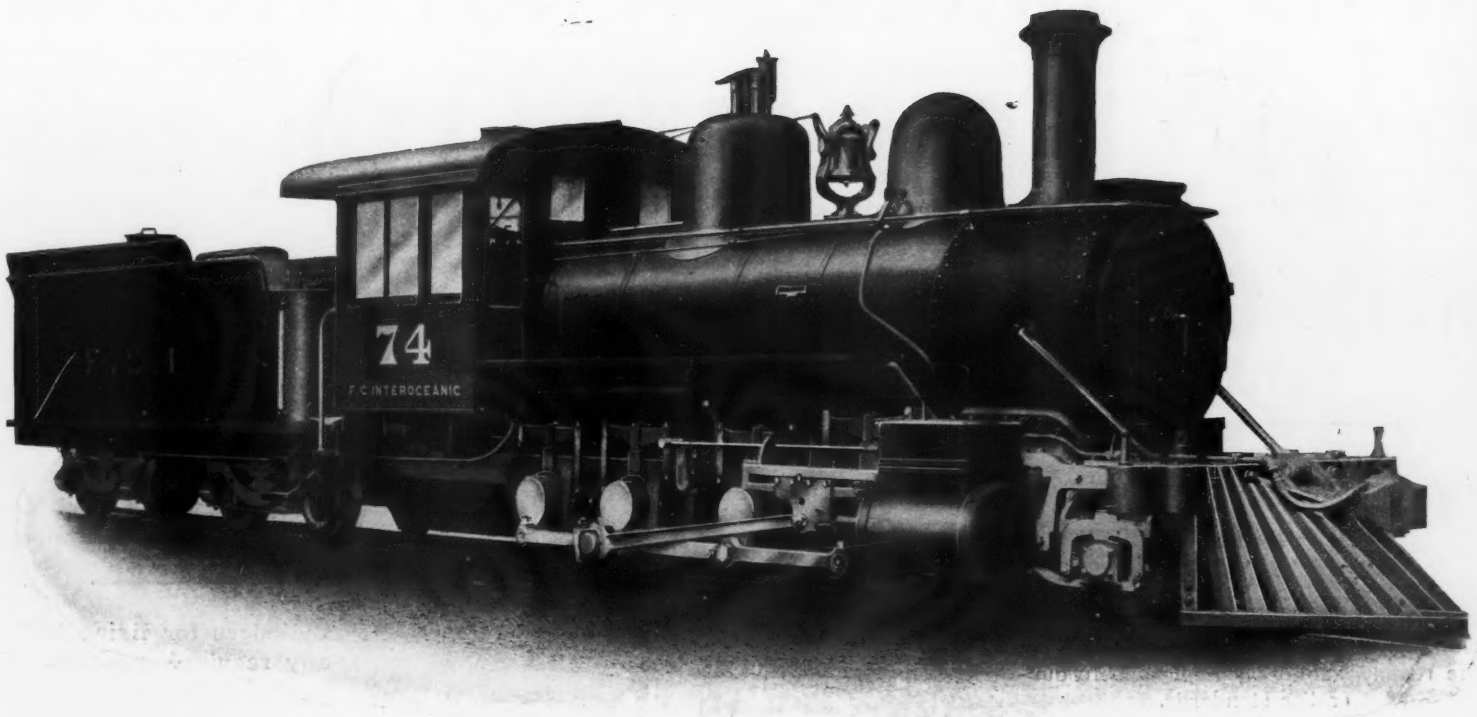

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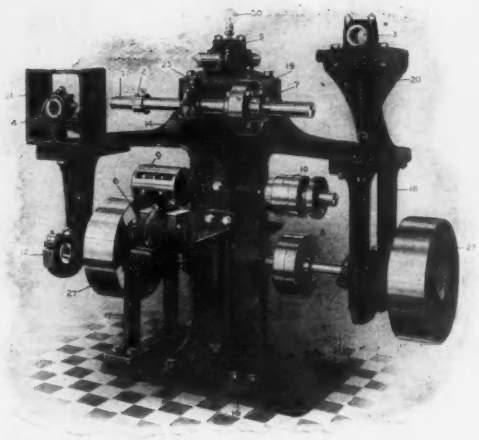

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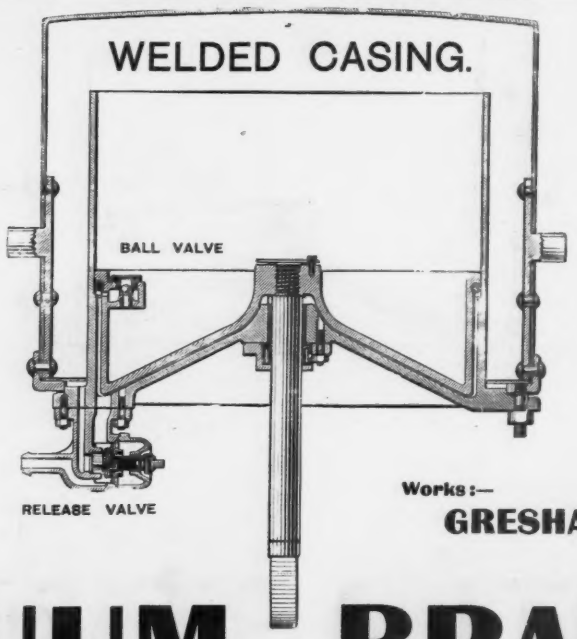

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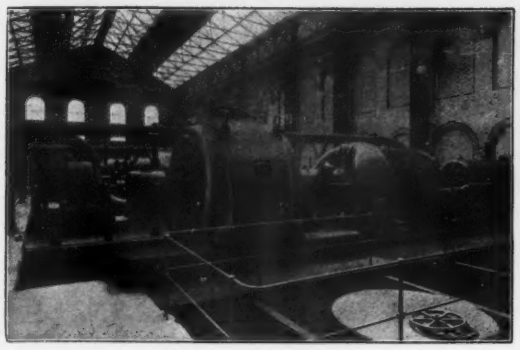

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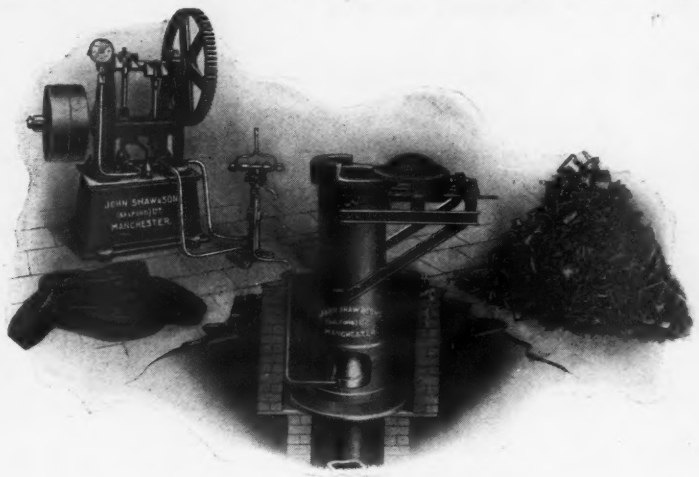

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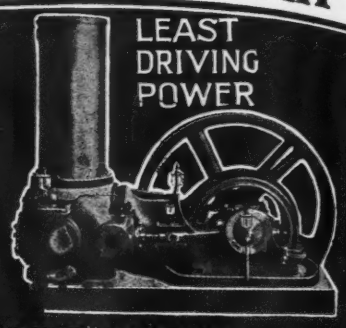

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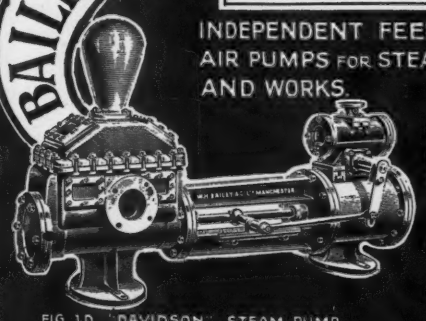

FIG. 1D. "DAVIDSON" STEAM PUMP

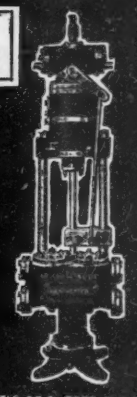

FIG. 50 D FEED PUMP

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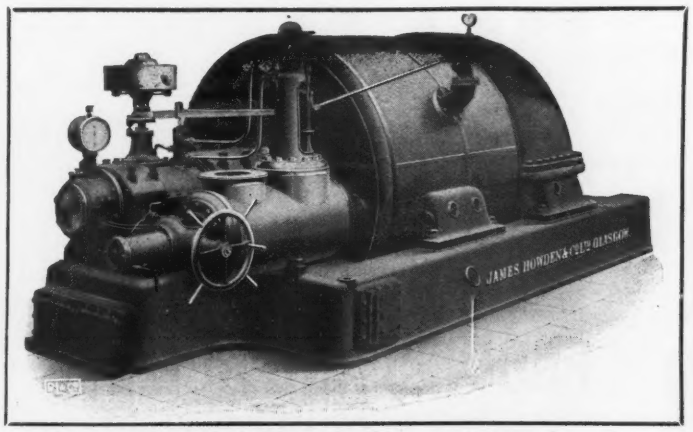

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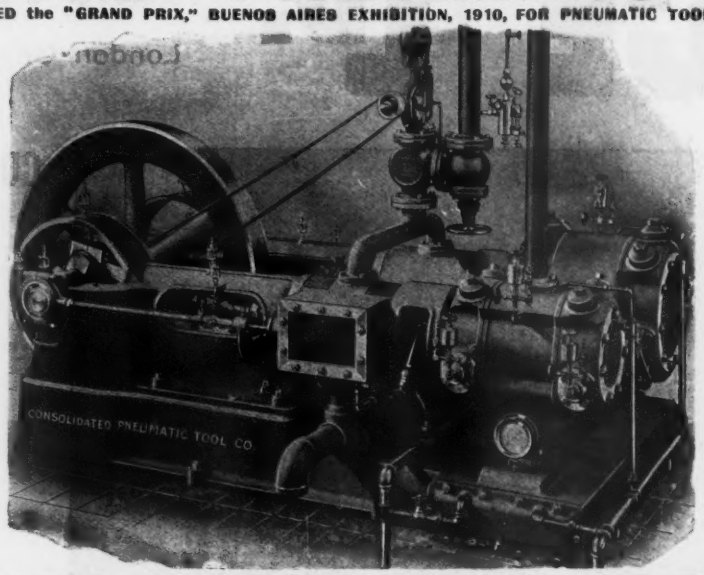

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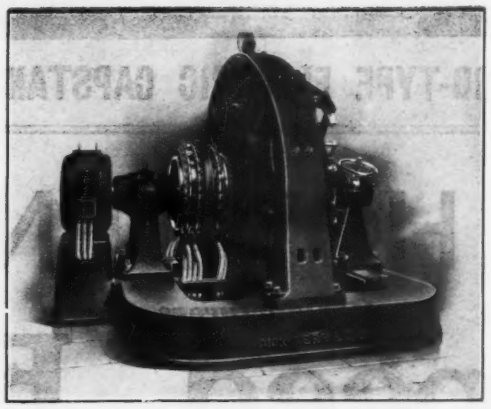

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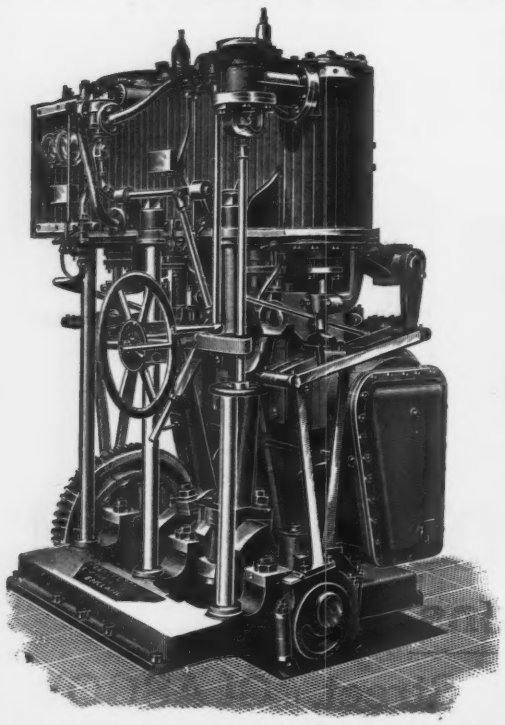

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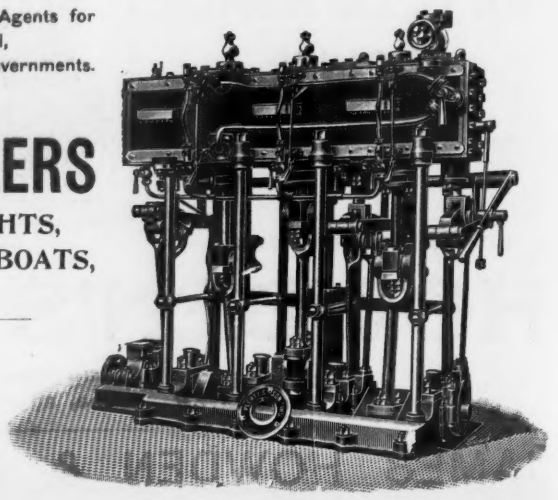

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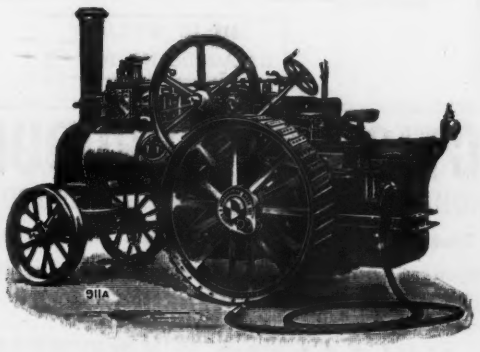

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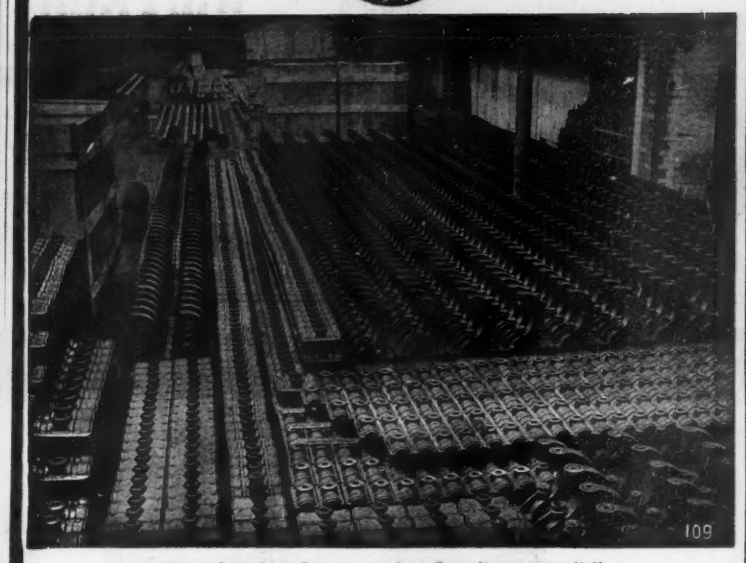

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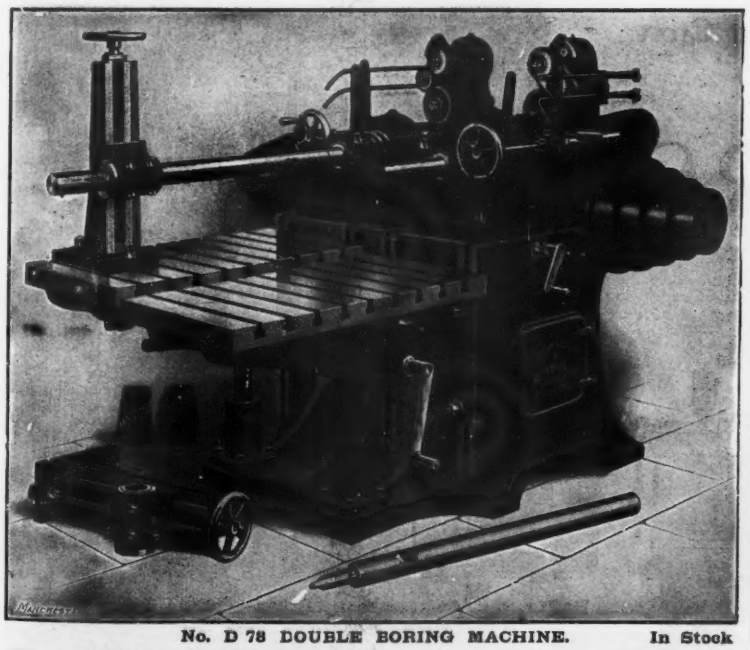

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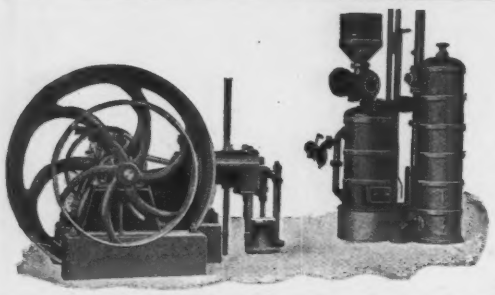

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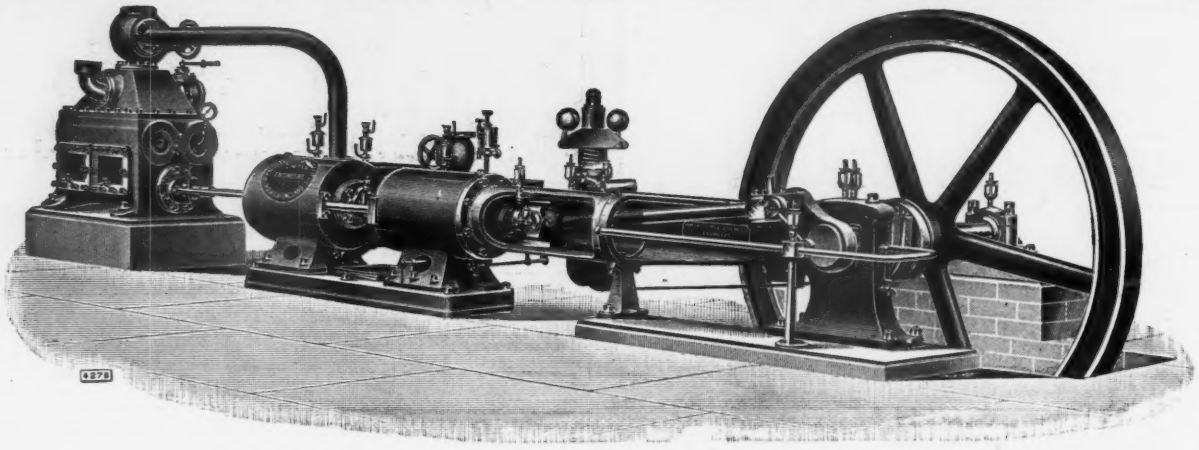

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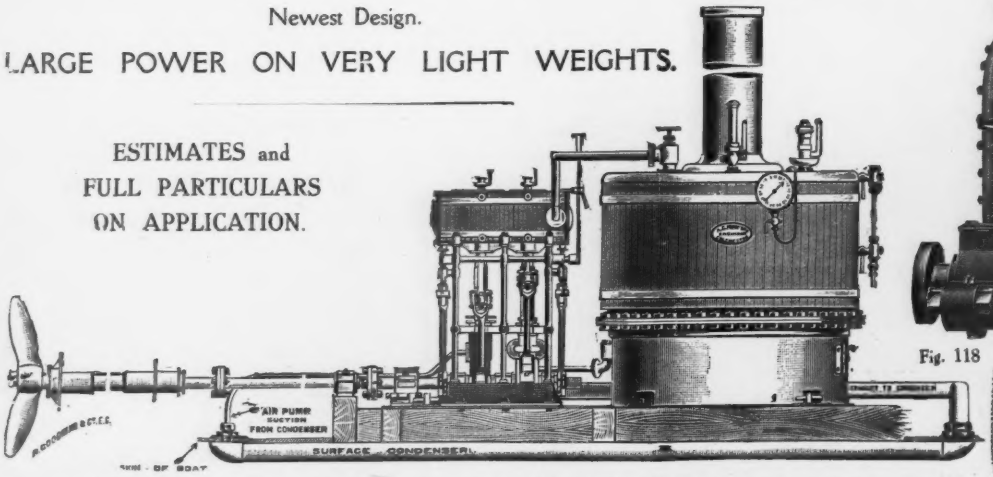

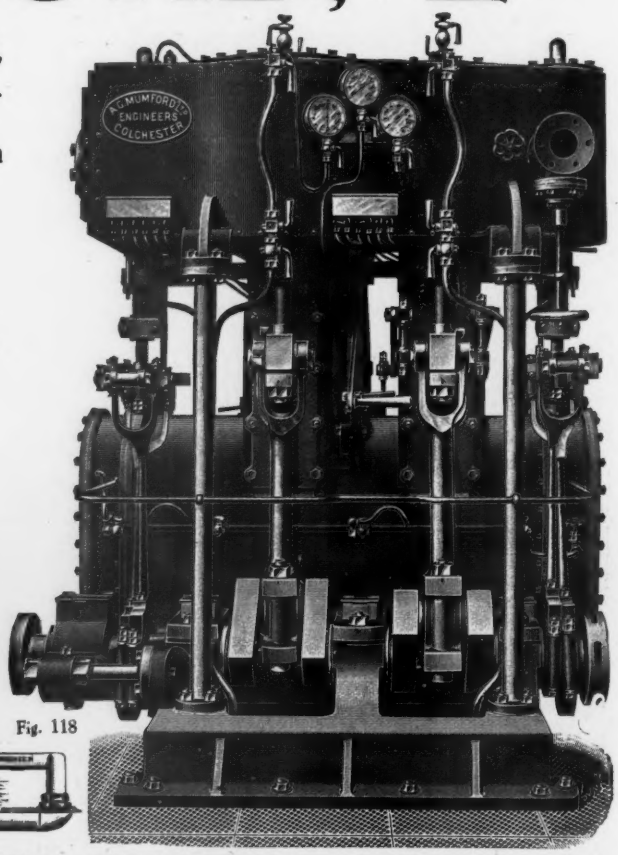

Fig. 118

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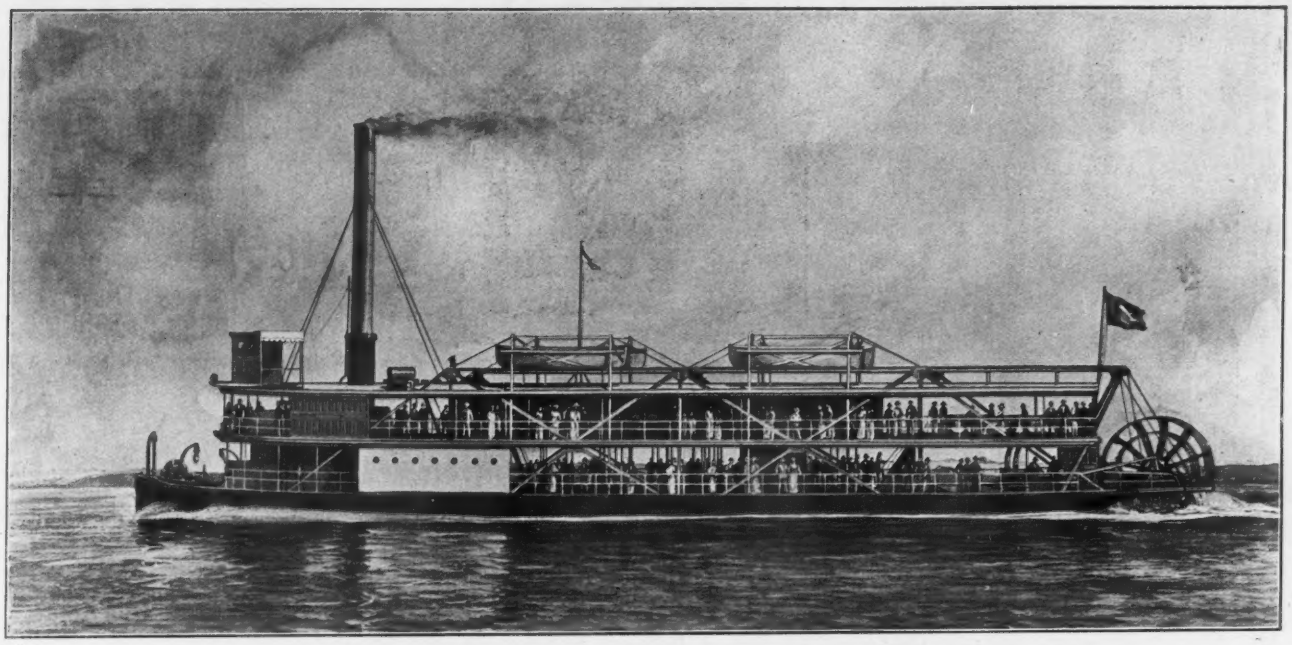

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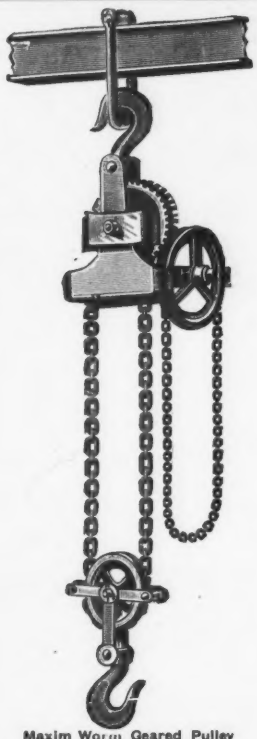

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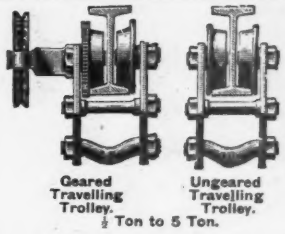

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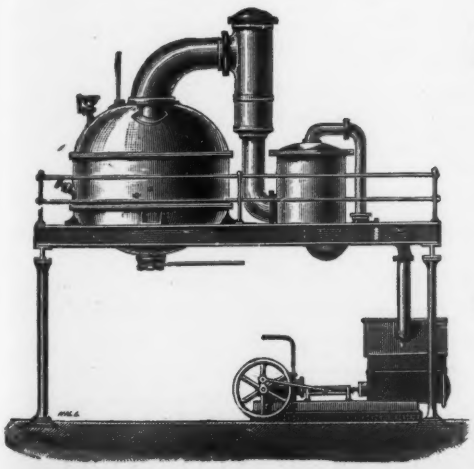

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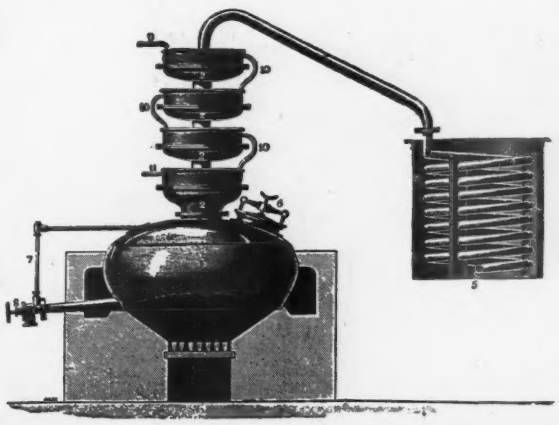

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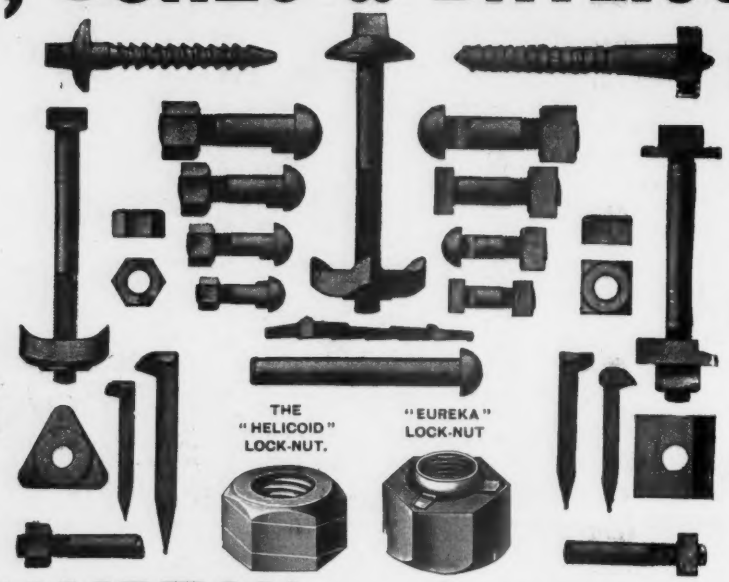

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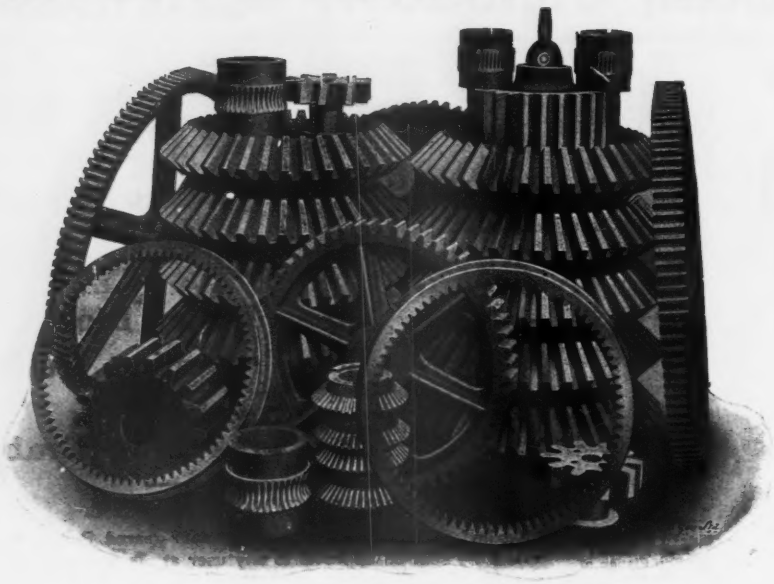

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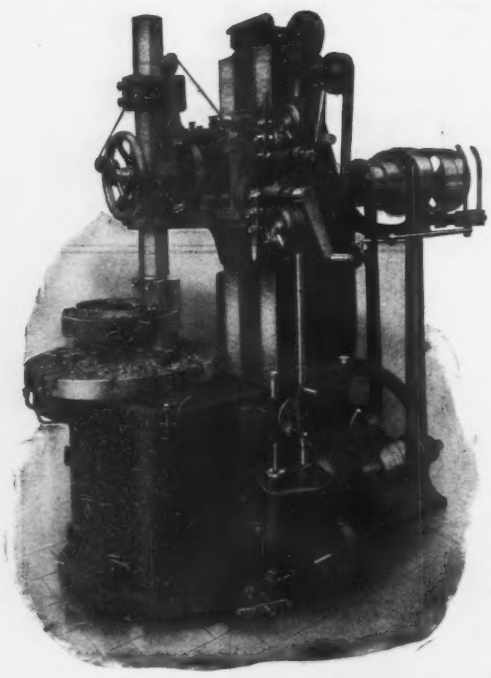

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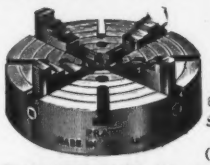

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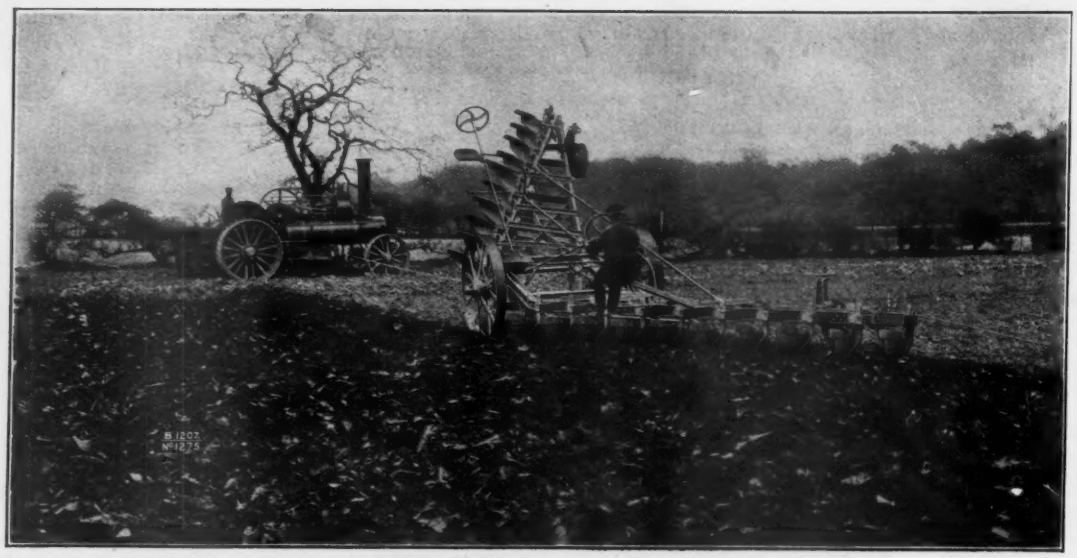

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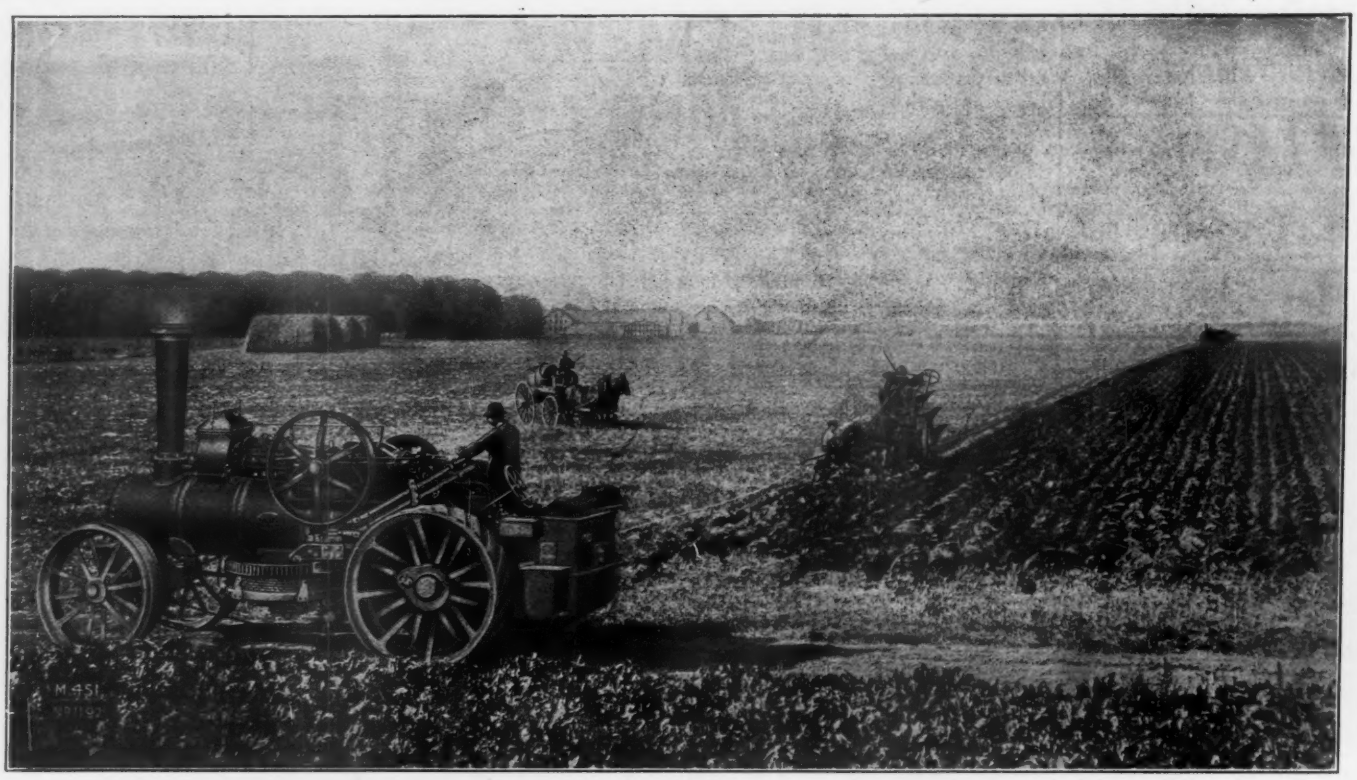

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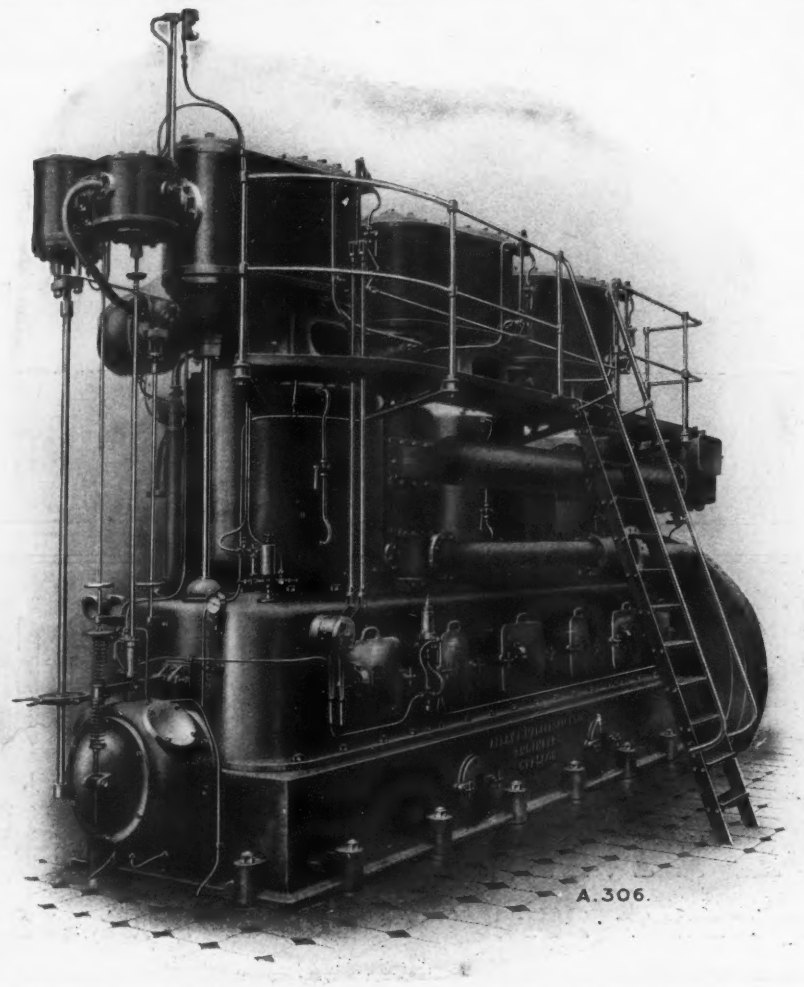

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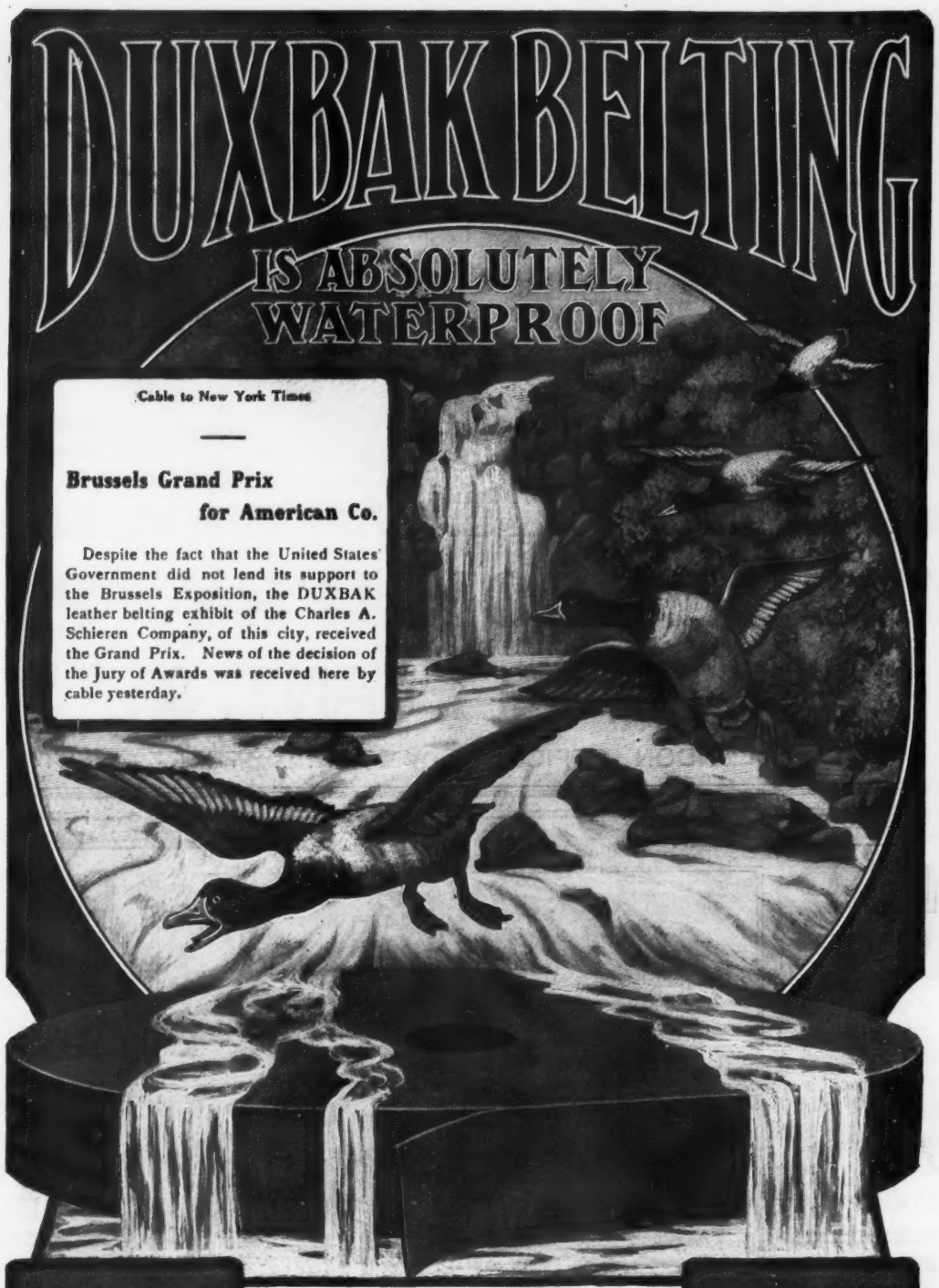

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Brussels Grand Prix for American Co.

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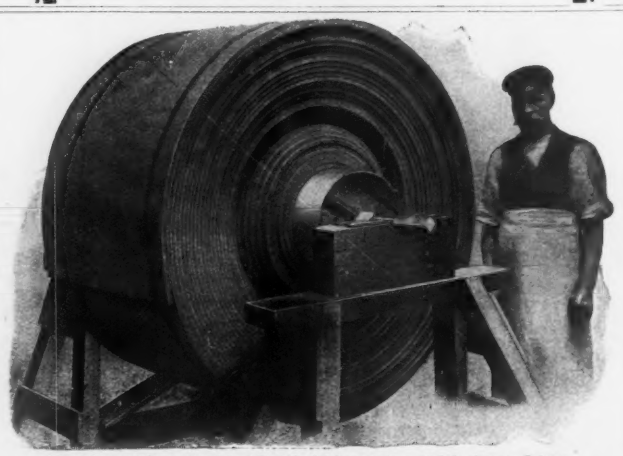

The above belt, made for a South African mine, weighed over 2 tons.

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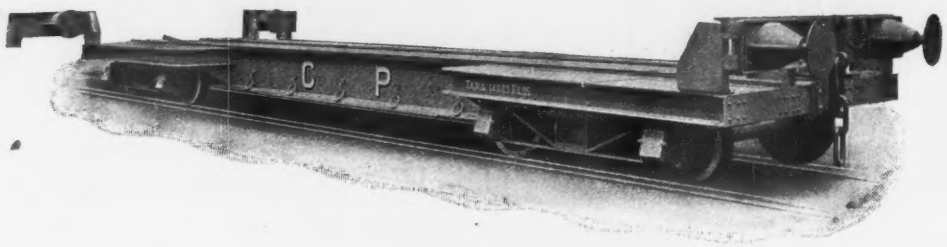

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which deals fully with the Landis Patent All-Steel Die Head.

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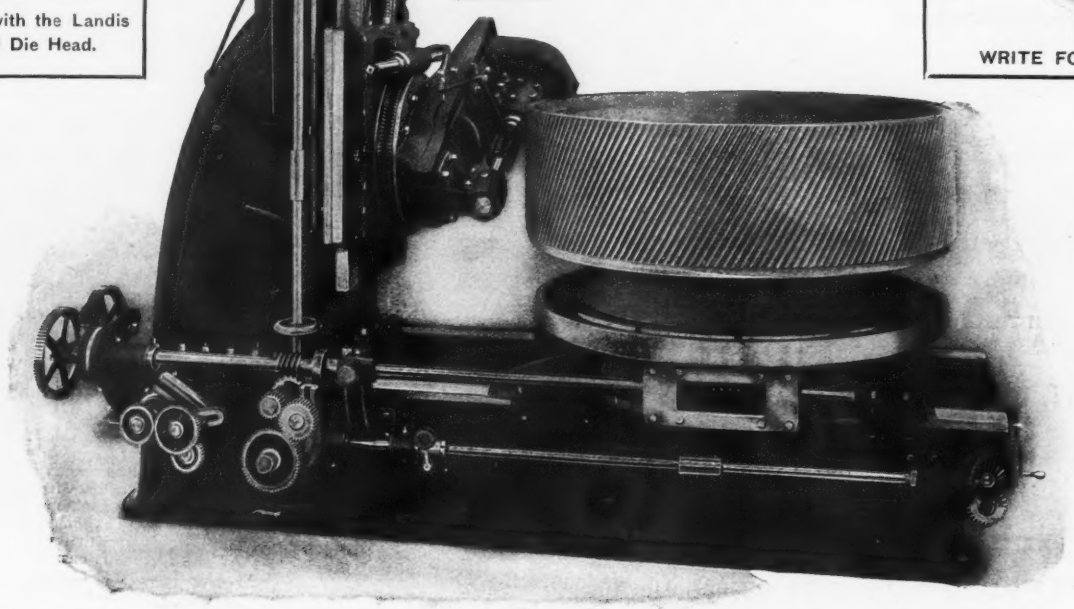
WRITE FOR LIST F 14.

PATENT AUTOMATIC GEAR HOBBING MACHINES

for hobbing Spur, Worm, and Spiral Gears in all sizes from ½in. to 15ft. diameter.

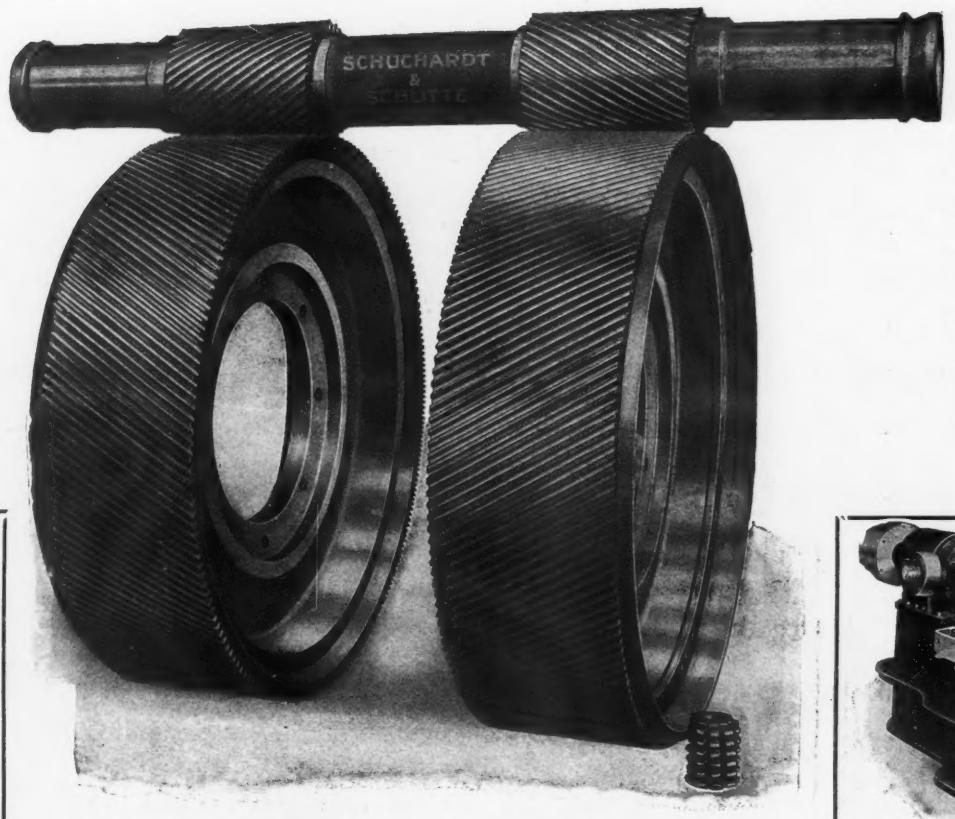


VISIT OUR SHOWROOMS.

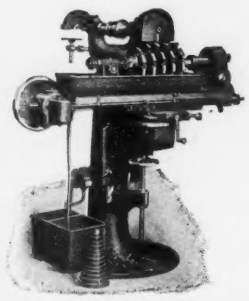
WRITE FOR LIST OF USERS.

No. 5 GEAR HOBBER, which hobbed the 78in. x 20in. Turbine Reduction Gears illustrated below.

Our Patent Automatic Gear Hobbing Machines are built in 10 sizes for hobbing Spur, Worm, and Spiral Gears from ½in. to 15ft. diameter. Larger sizes to specification.

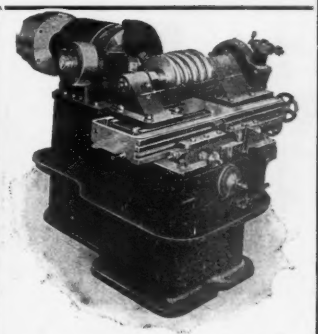


Over 1400 of our Gear Hobbers are in actual use. We always have several machines under belt in our Palmer St. Showrooms.



HOB GRINDER, for work up to 17in. long x 10in. diameter.

TURBINE REDUCING GEARS
78in. x 20in.
hobbed on No. 5 Patent Automatic Gear Hobber. D183

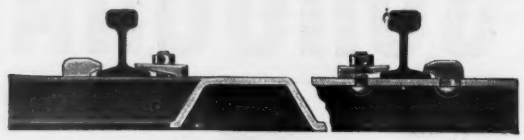


WORM MILLING MACHINE specially adapted for Milling Worms for back axle drives, &c.

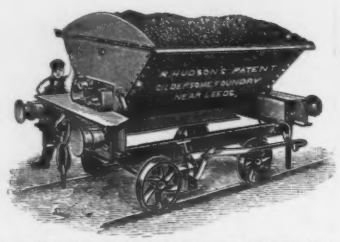
RAILS.

No. E 191.—**Corrugated Steel Sleeper,** with Clutch Bolt and Rivetted Clip.

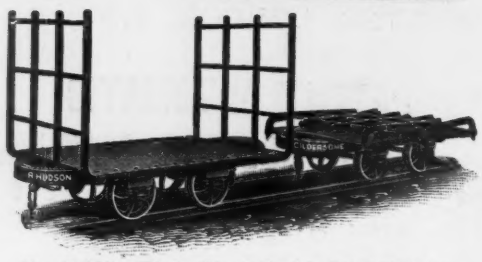
SLEEPERS.



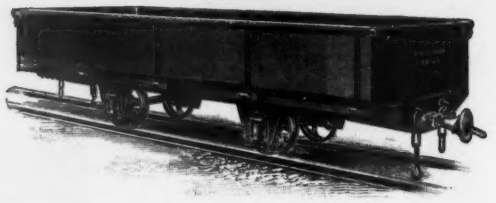
No. E 190.—**Steel Trough Sleeper,** with Bolted Clips.



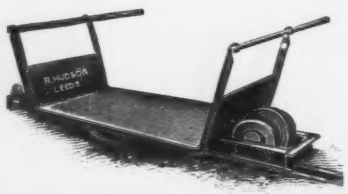
No. E 59.—**Patent Double Side Tip Wagon.** To work with ordinary Railway Wagons made to any size. Can be tipped by one man with ease.



No. E 409.—**Plain Steel Sugar Cane Wagon,** with Folding Ends and Steel Platform.

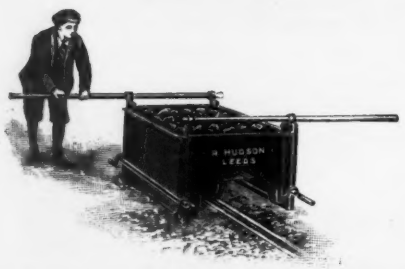


No. E 462.—**Open Goods Wagon** with Side Doors hinged full length.



No. E 460.—**Monorail Truck** for General Purposes.

No. E 484.—**Monorail Track.**



No. E 485.—**Monorail Hopper Quartz Truck** for tipping into Bins and Chutes.

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Complete Monorail Installations, Points & Crossings, Tip Wagons, &c.

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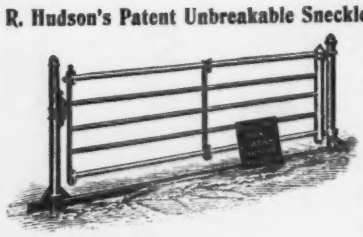

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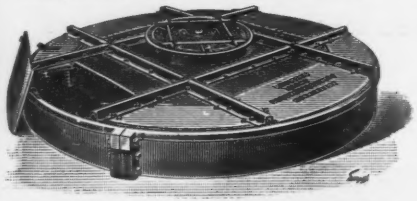
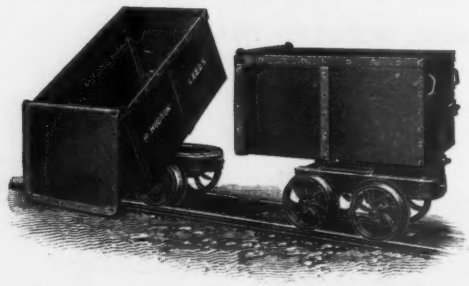
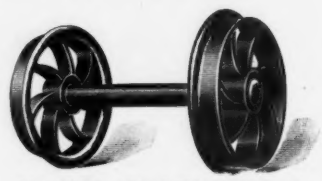


No. E 115.—**Self-contained Turntable.**

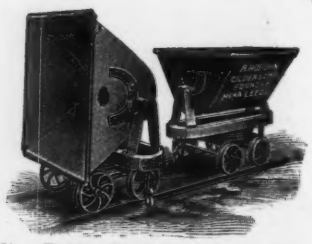


No. E 482.—**Side and End Tip Mining Car** with End Door.

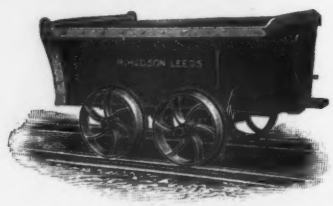


No. E 91.—**Cast Steel Wheels** fast on Steel Axles.

No. E 68.—**Cake Drying Wagon.**



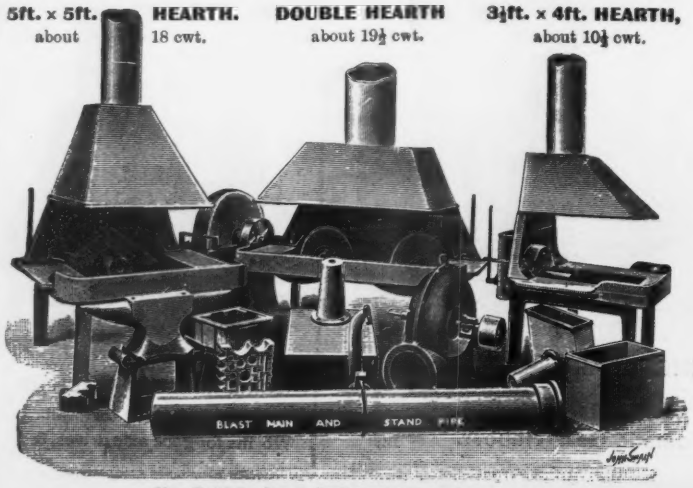
No. E 50.—**Double Centre Universal Tipping Wagon.**



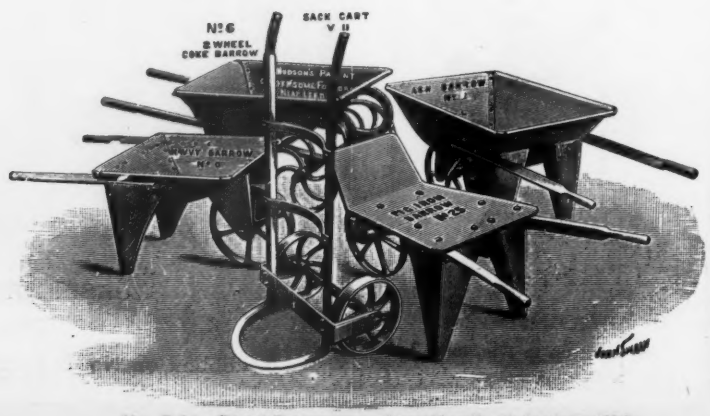
No. E 491.—**Steel Mining Tram,** with End Door.

No. E 112.—**Tipping Bucket** for Overhead Railway.

5ft. × 5ft. HEARTH. about 18 cwt. **DOUBLE HEARTH** about 19½ cwt. **3½ft. × 4ft. HEARTH,** about 10½ cwt.



No. E 122—**Iron Smiths' Hearths.**



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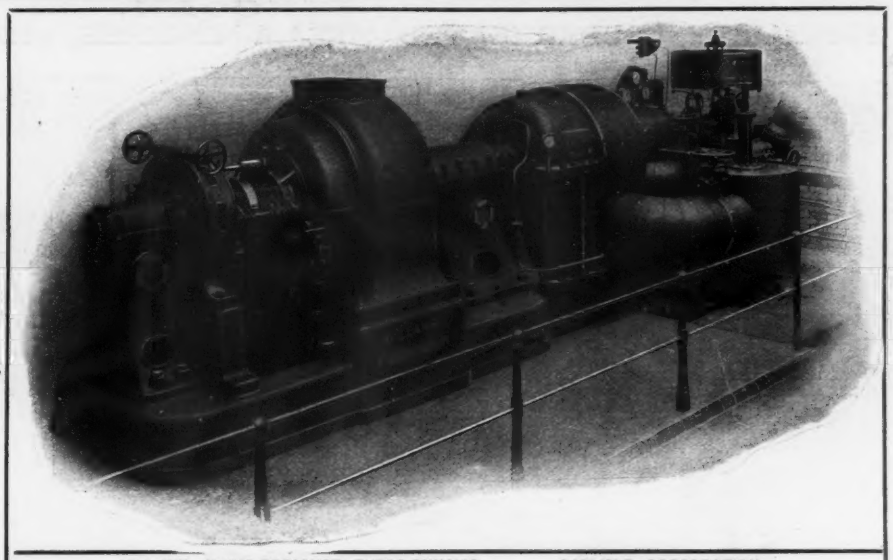

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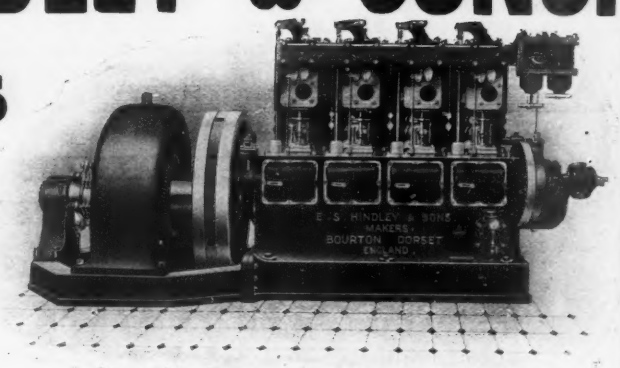

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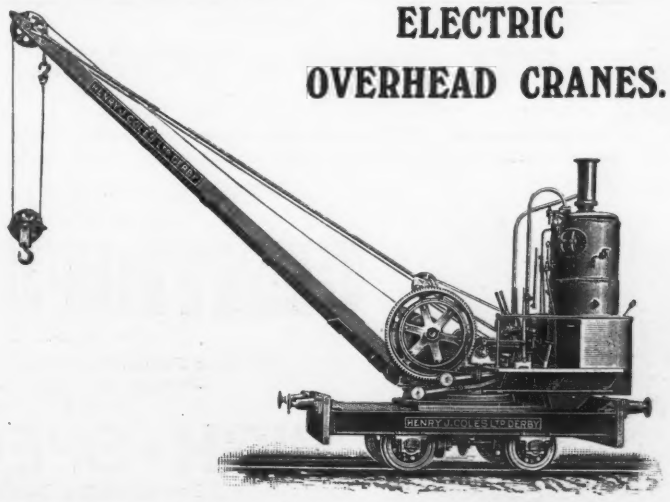

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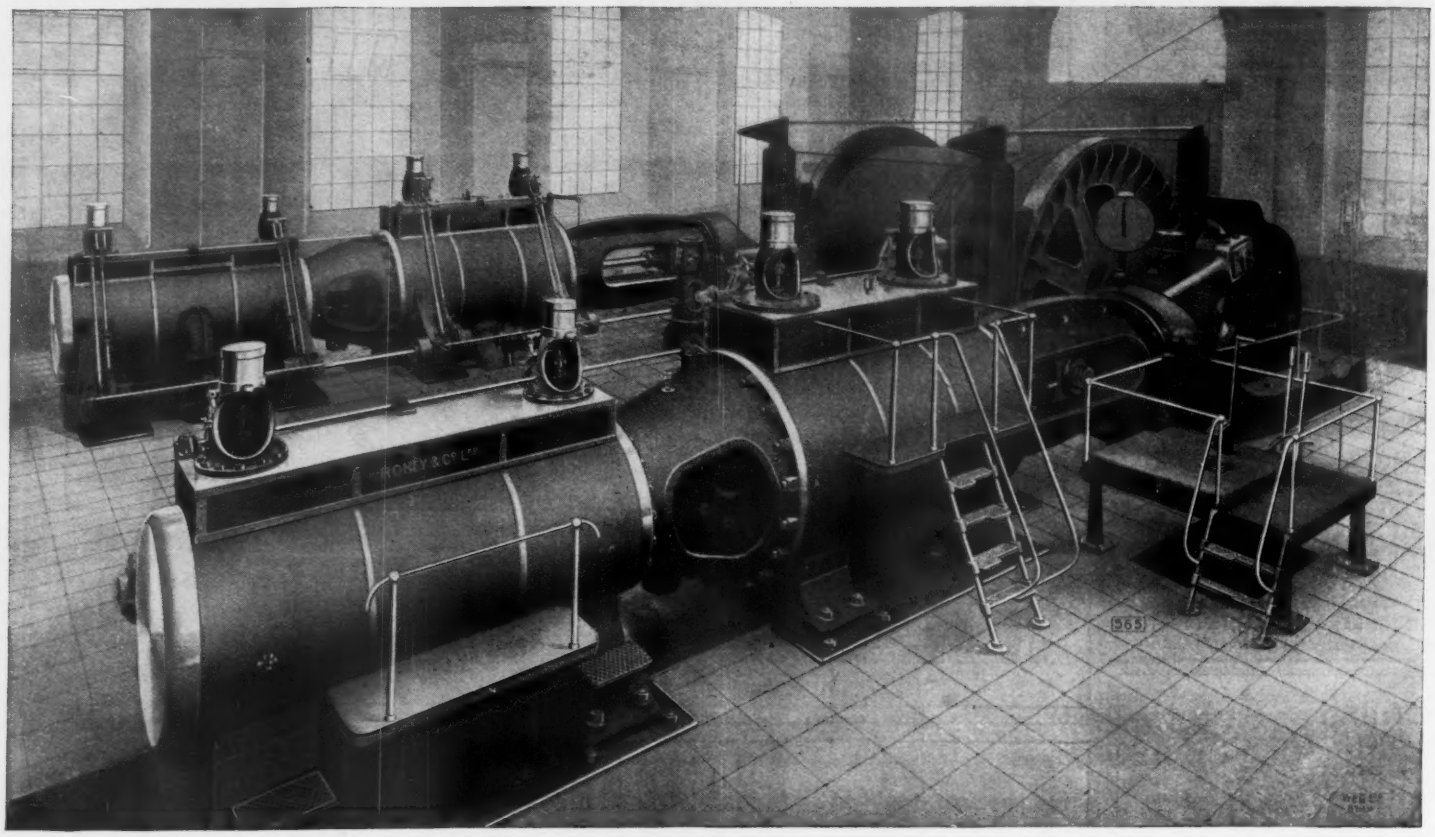

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With Patent Reversing Gear and Patent Device for Prevention of Overspeed and Overwinding.

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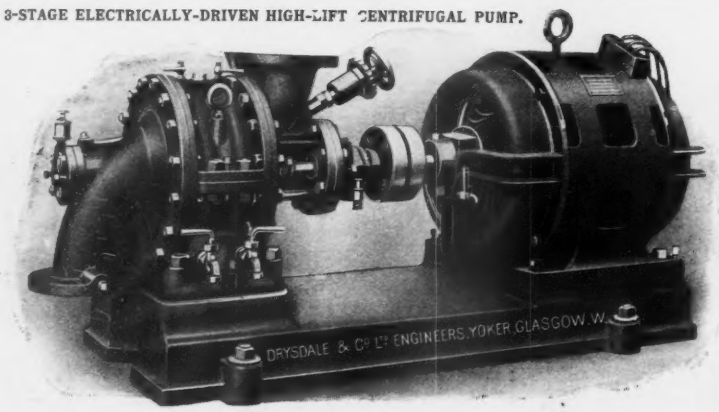

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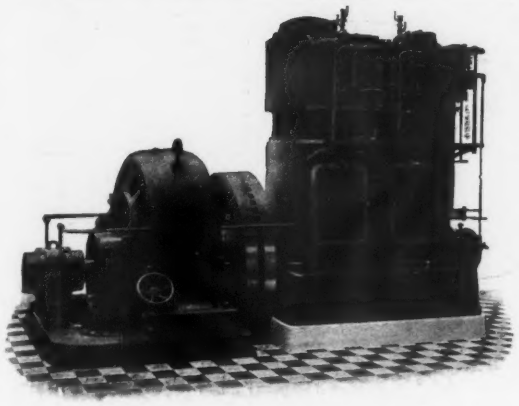

375 K.W. Two-Crank Compound Enclosed Engine and Continuous-current Dynamo.

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From 5 to 3000 Brake Horse-power.

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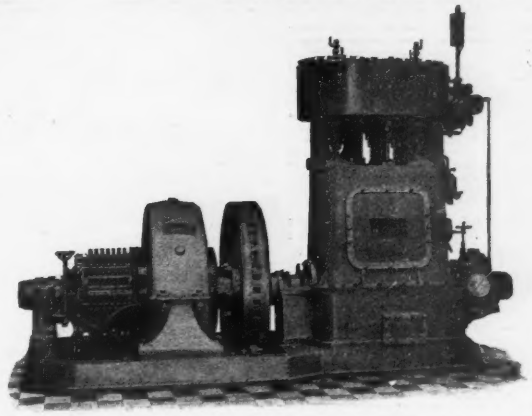

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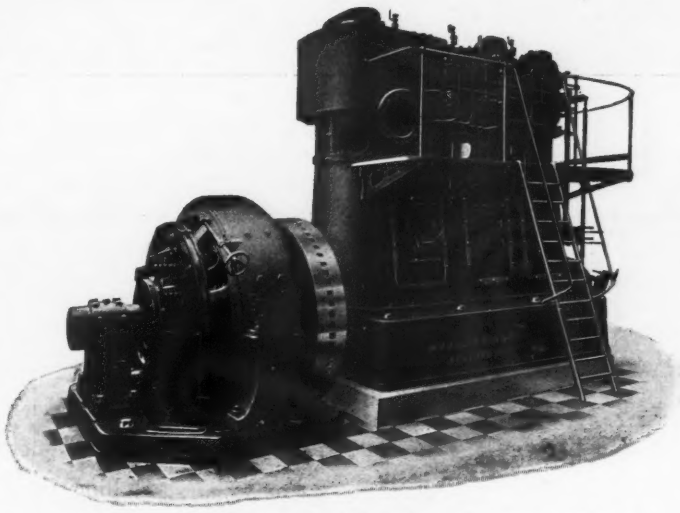

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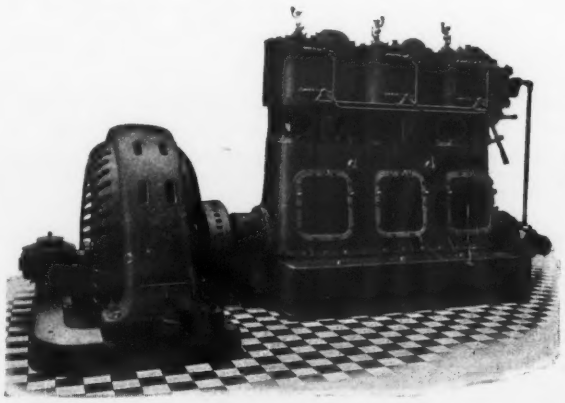

200 K.W. Three-Crank Compound Enclosed Engine and Alternator.

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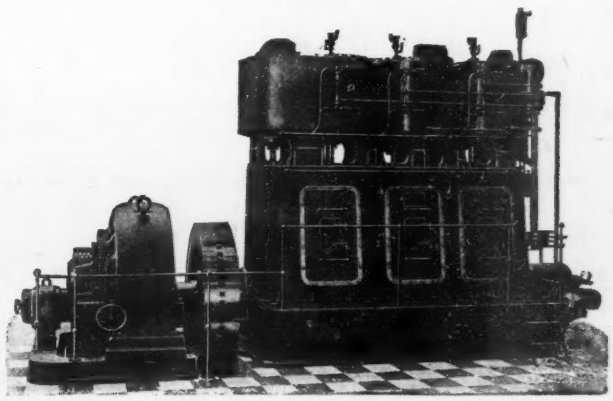

500 K.W. Triple-Expansion Enclosed Engine and Dynamo.

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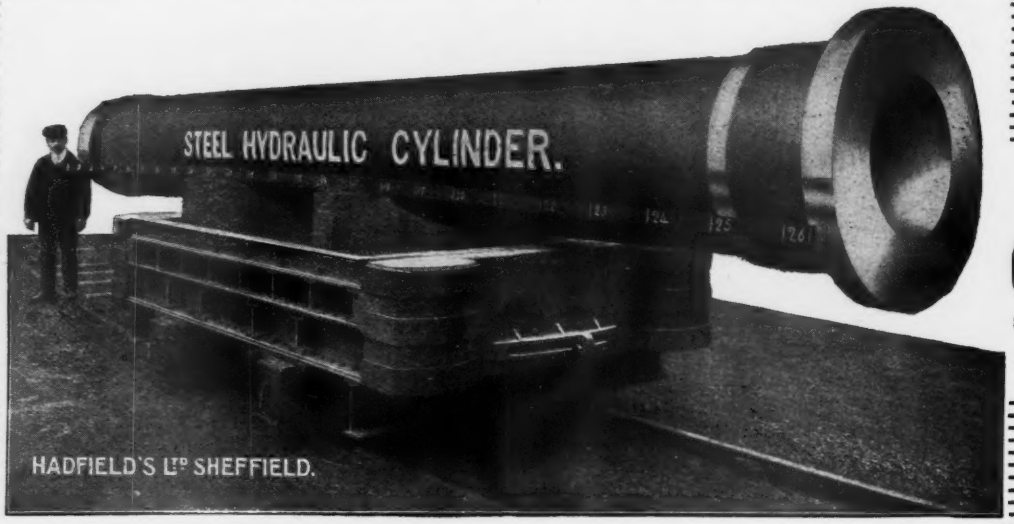

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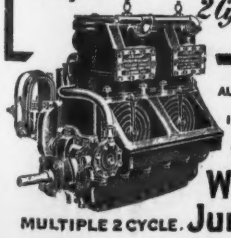
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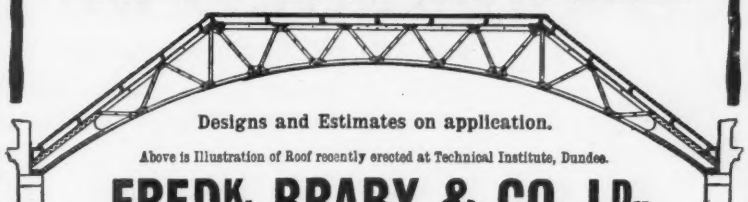
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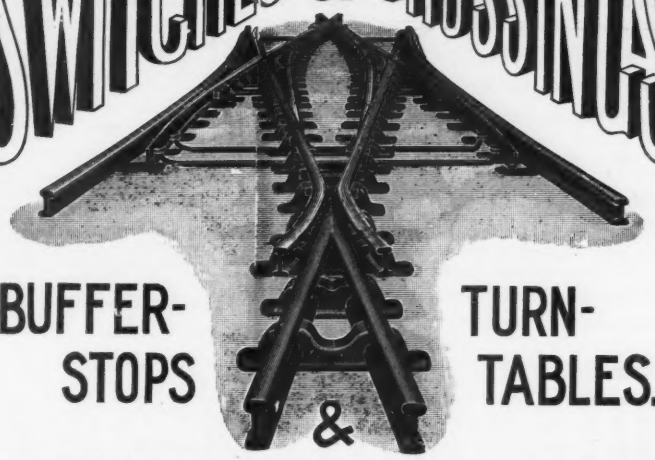
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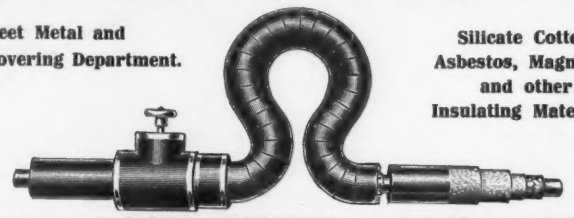
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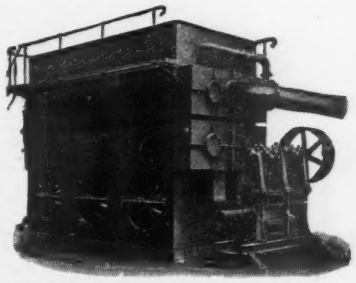
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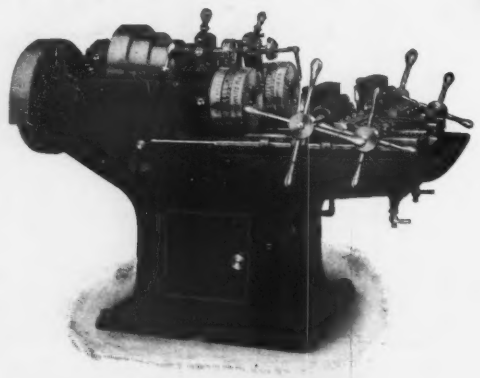

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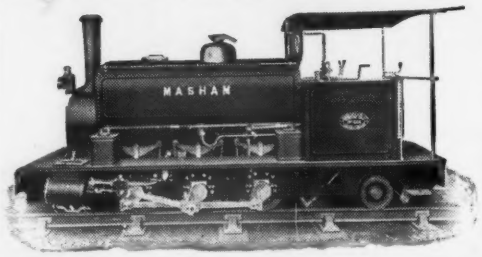

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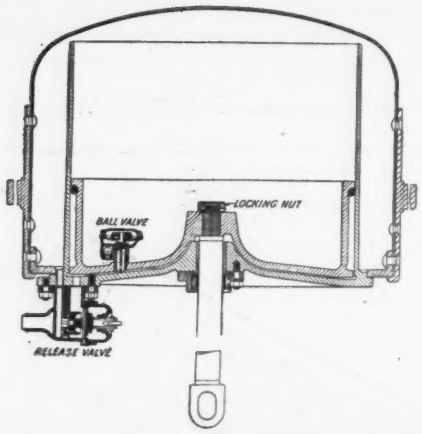

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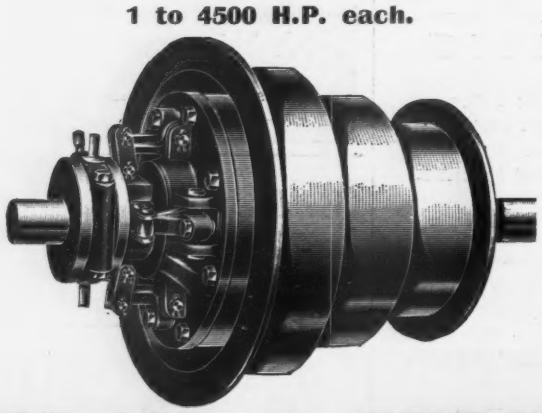

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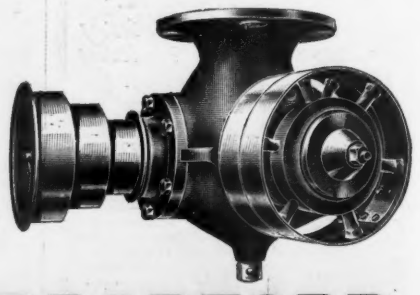

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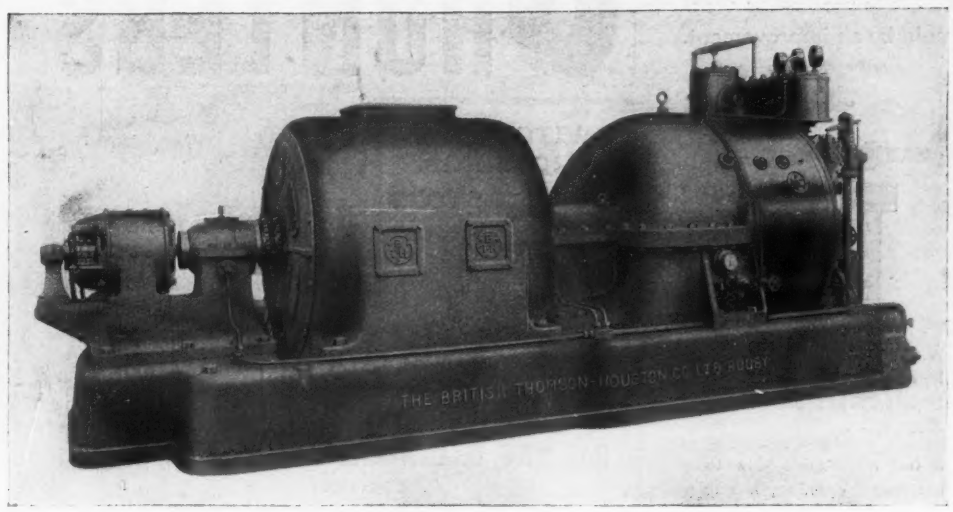

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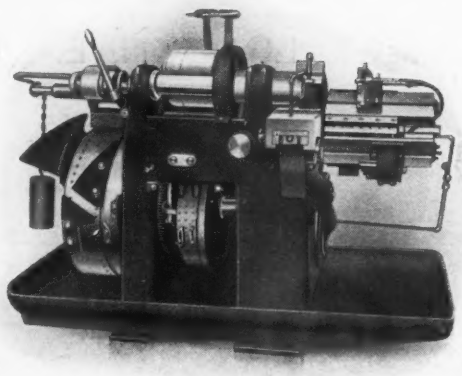

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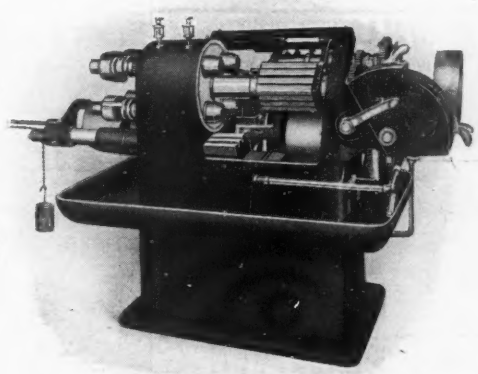

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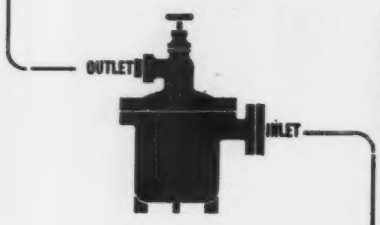

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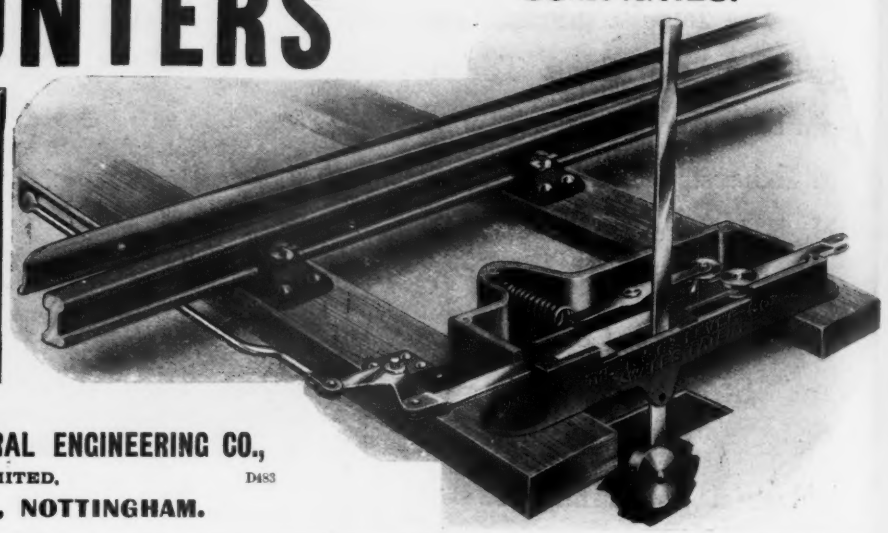

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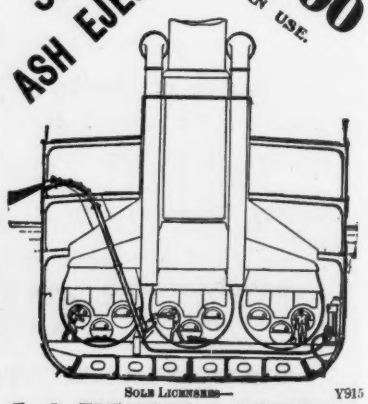

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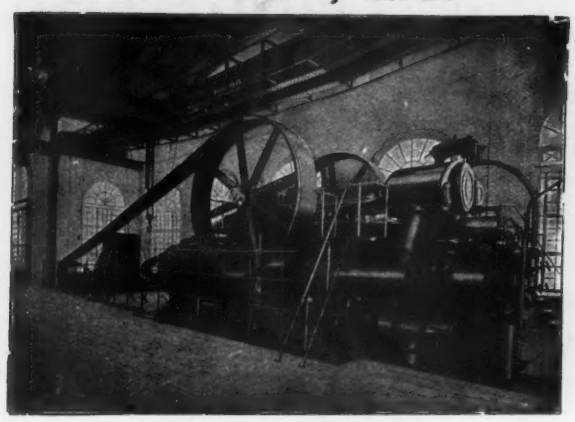

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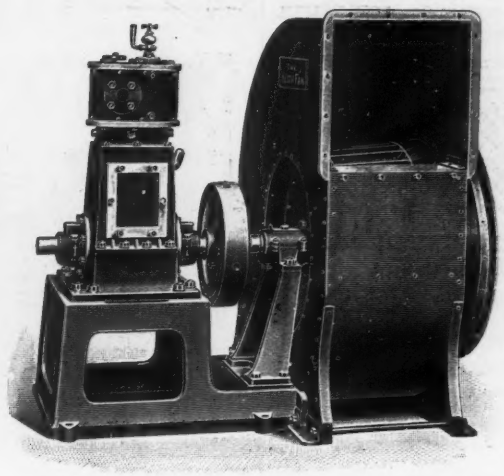

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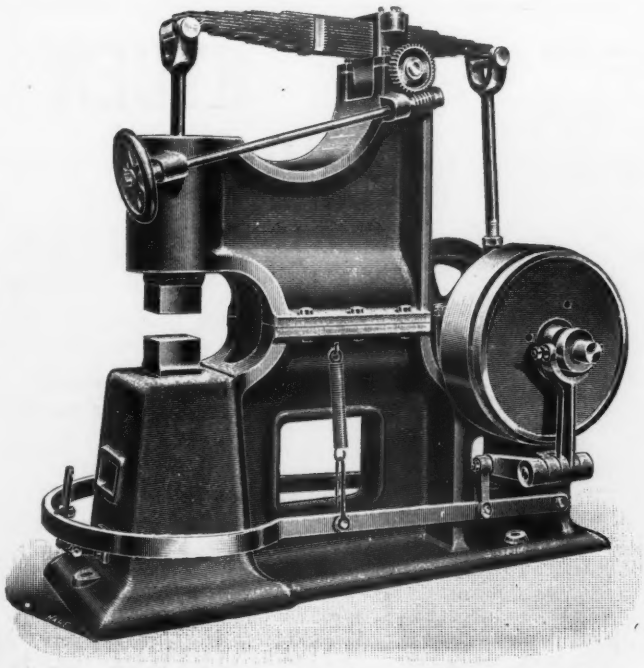

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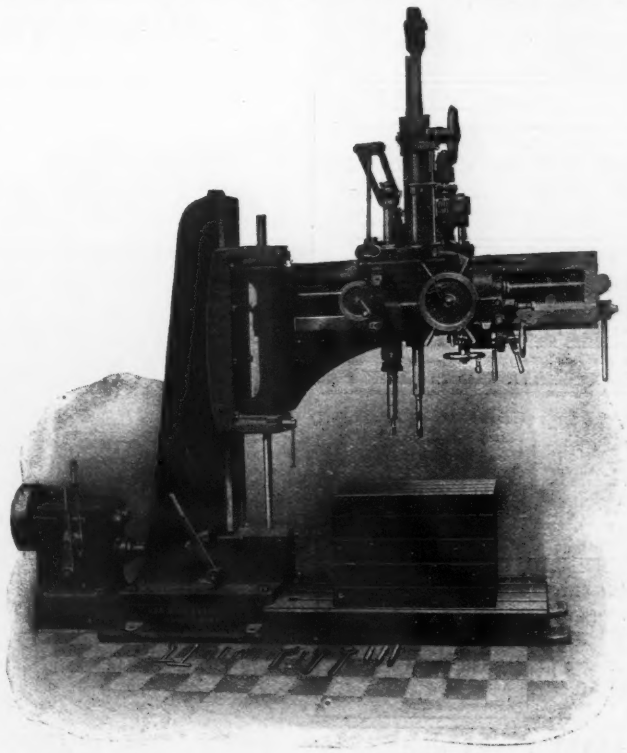

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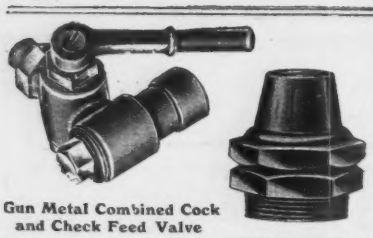

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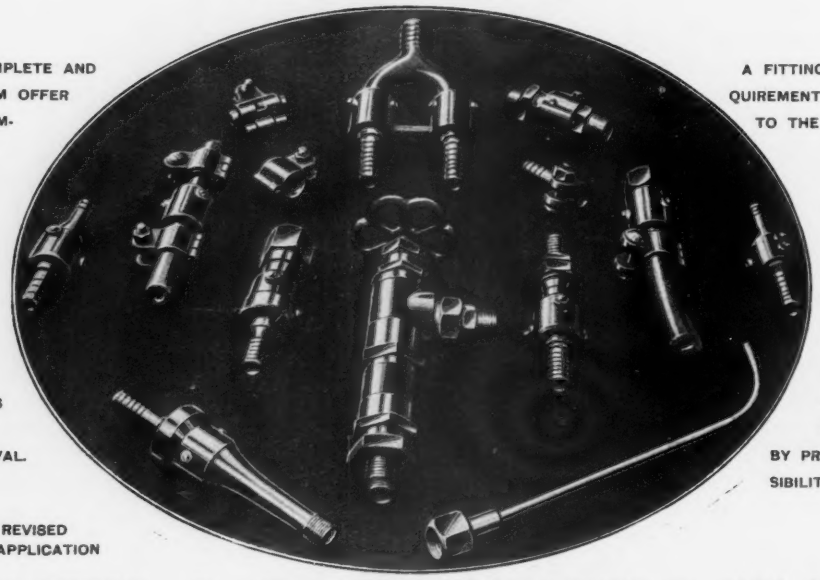

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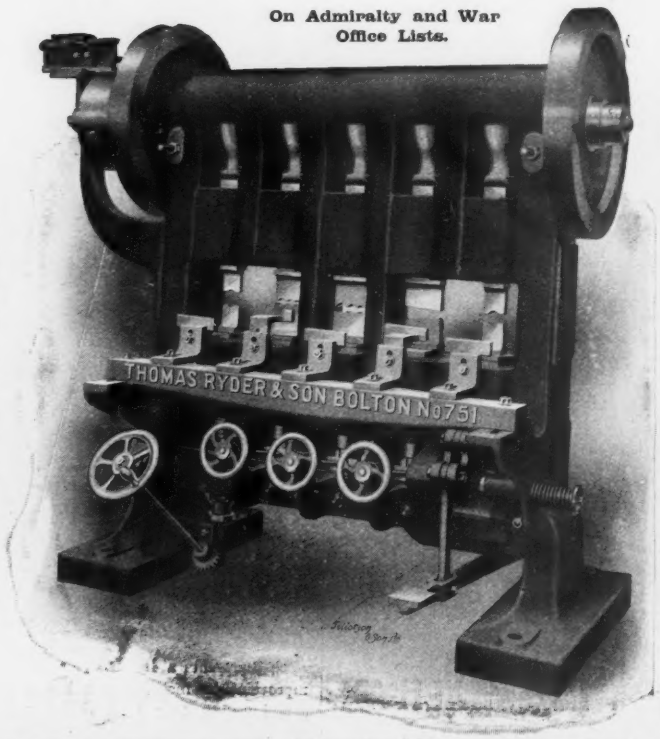

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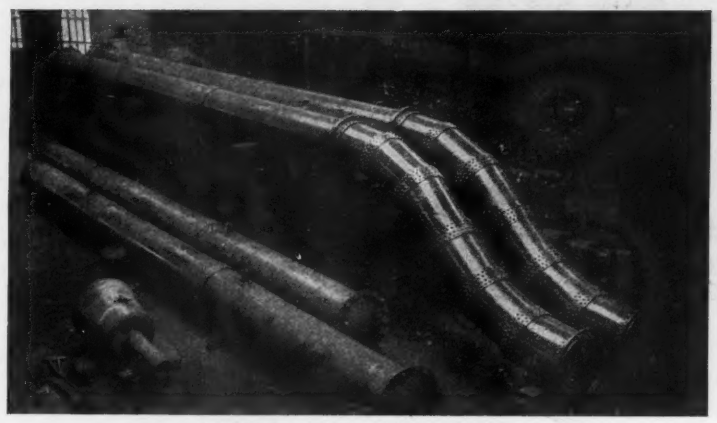

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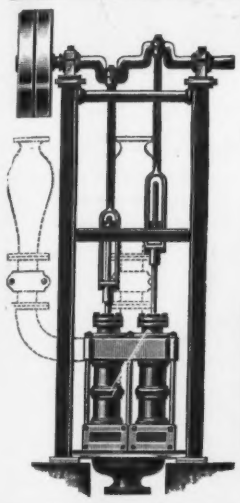

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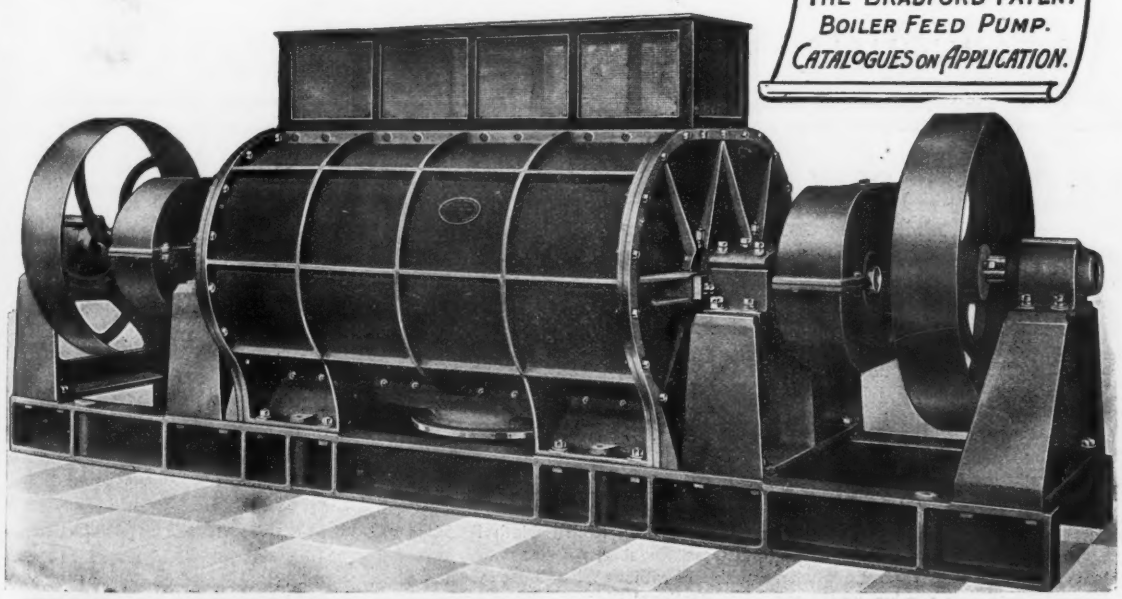

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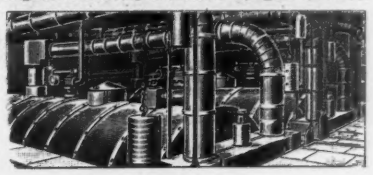

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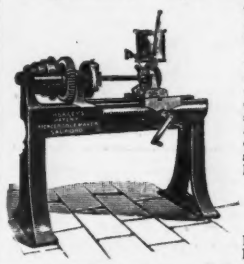

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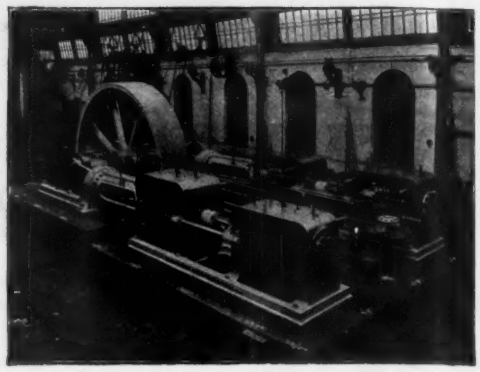

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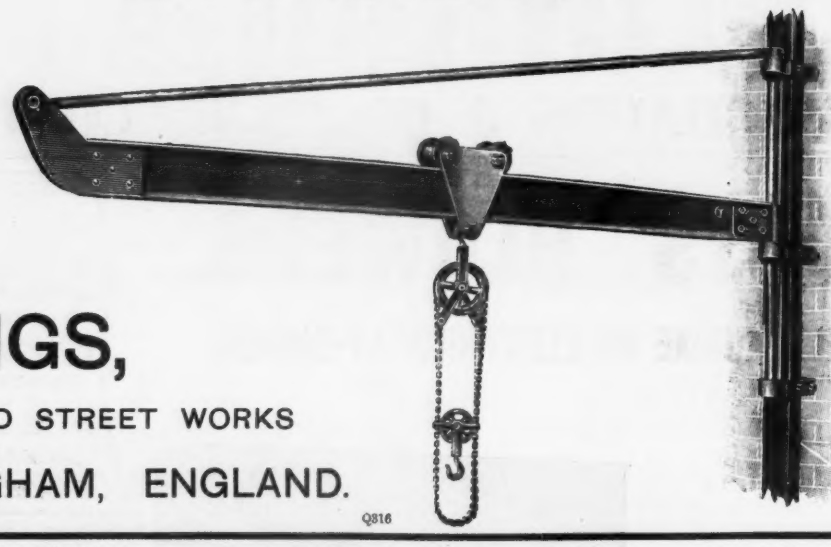

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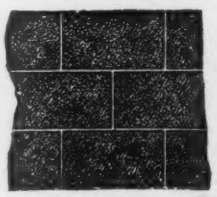

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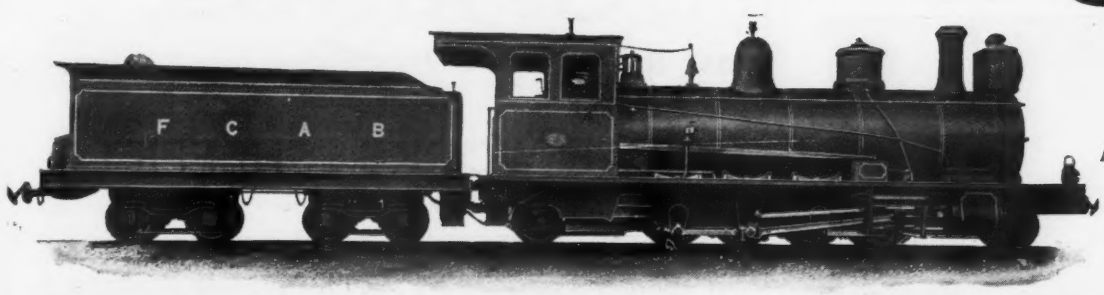

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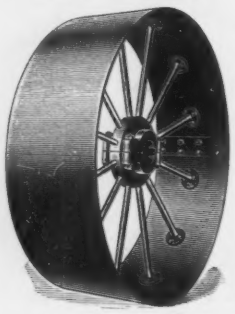

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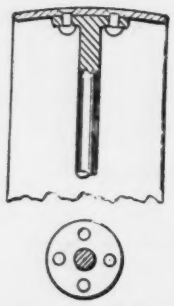

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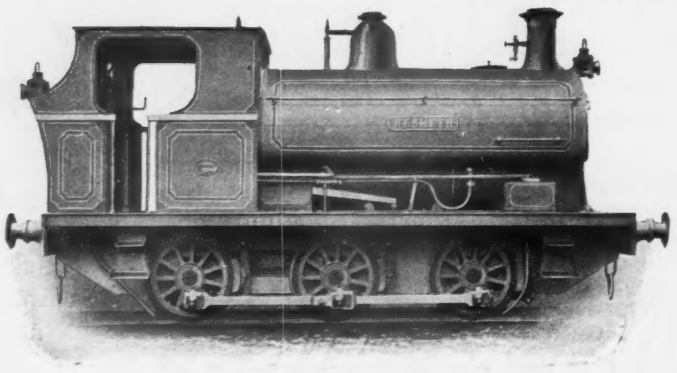

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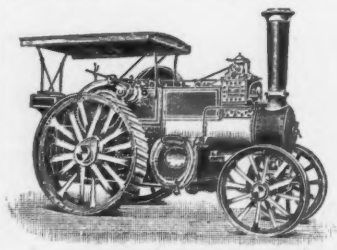

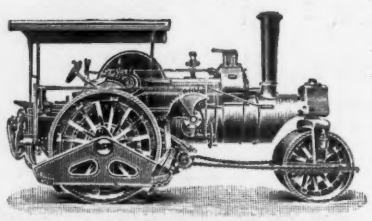

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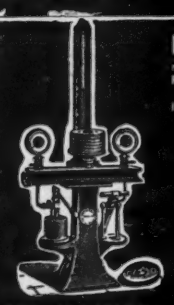

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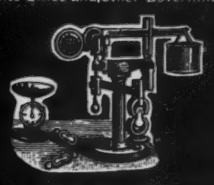

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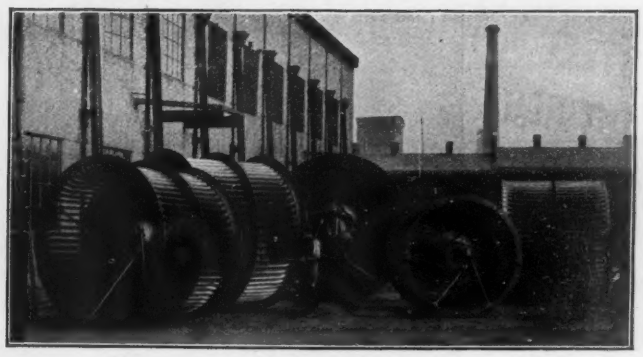

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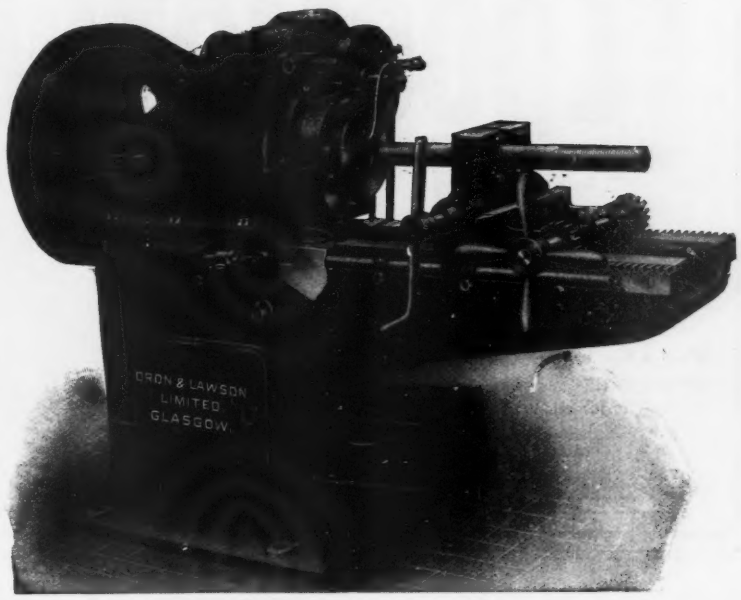

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Die Head **Opens and Closes Automatically** at the correct moment.
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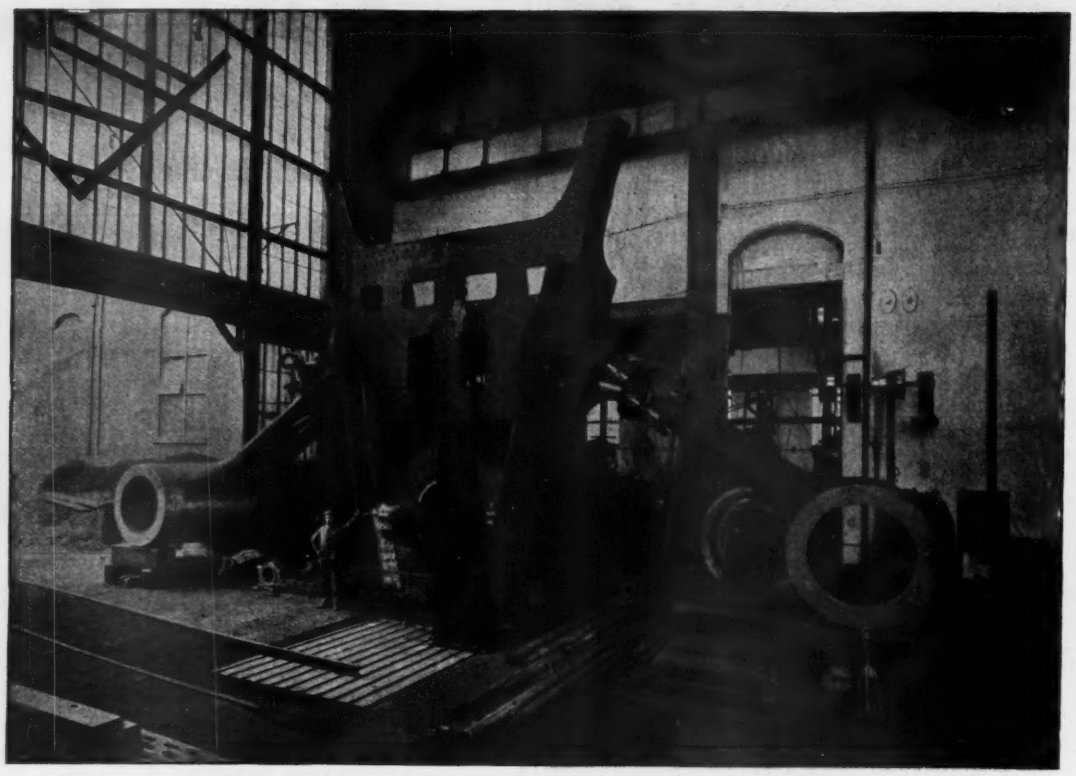

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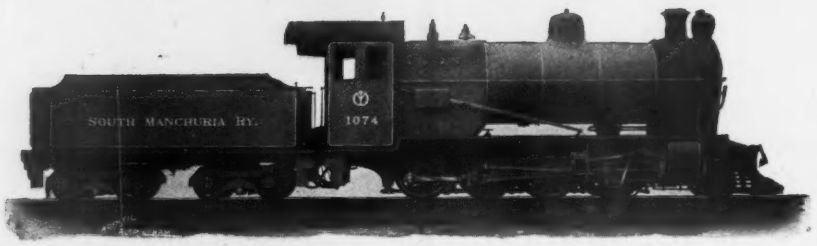

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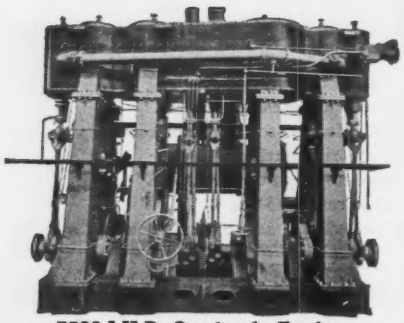

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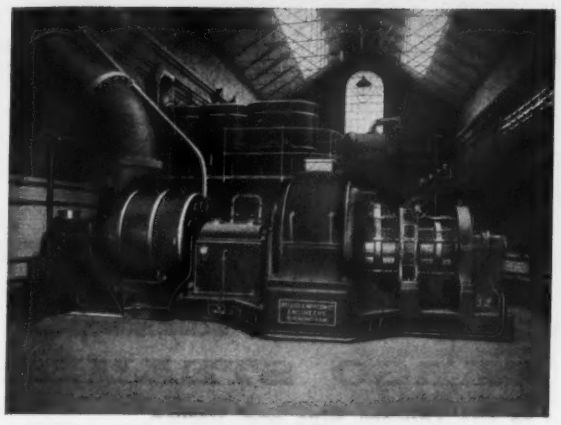

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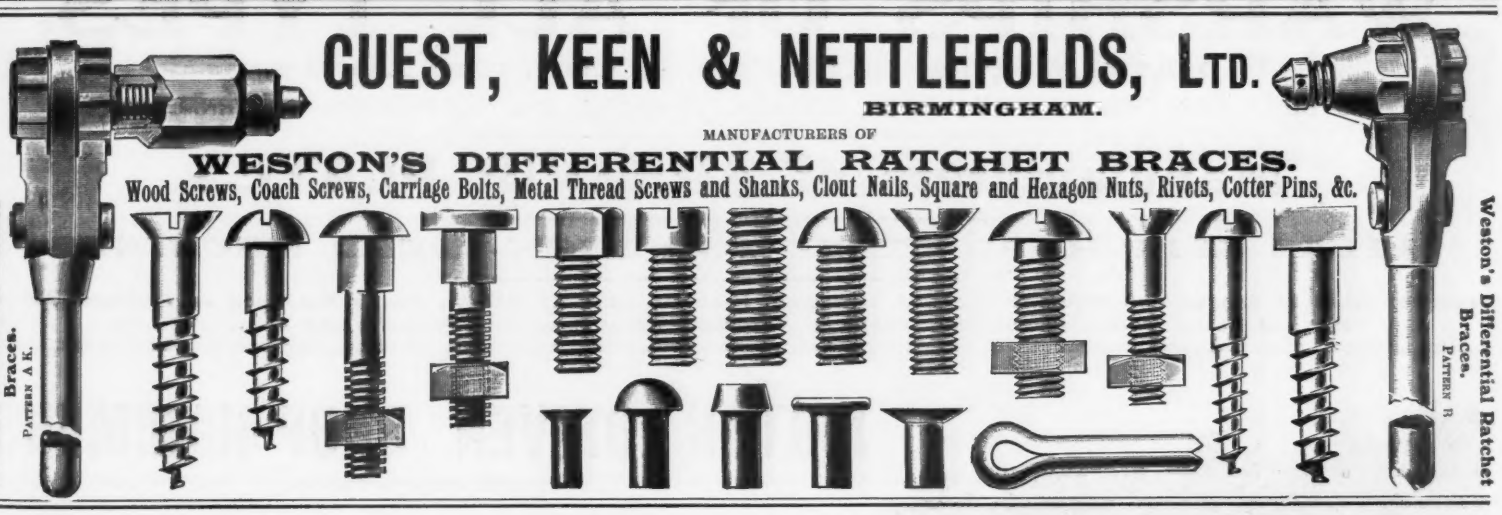

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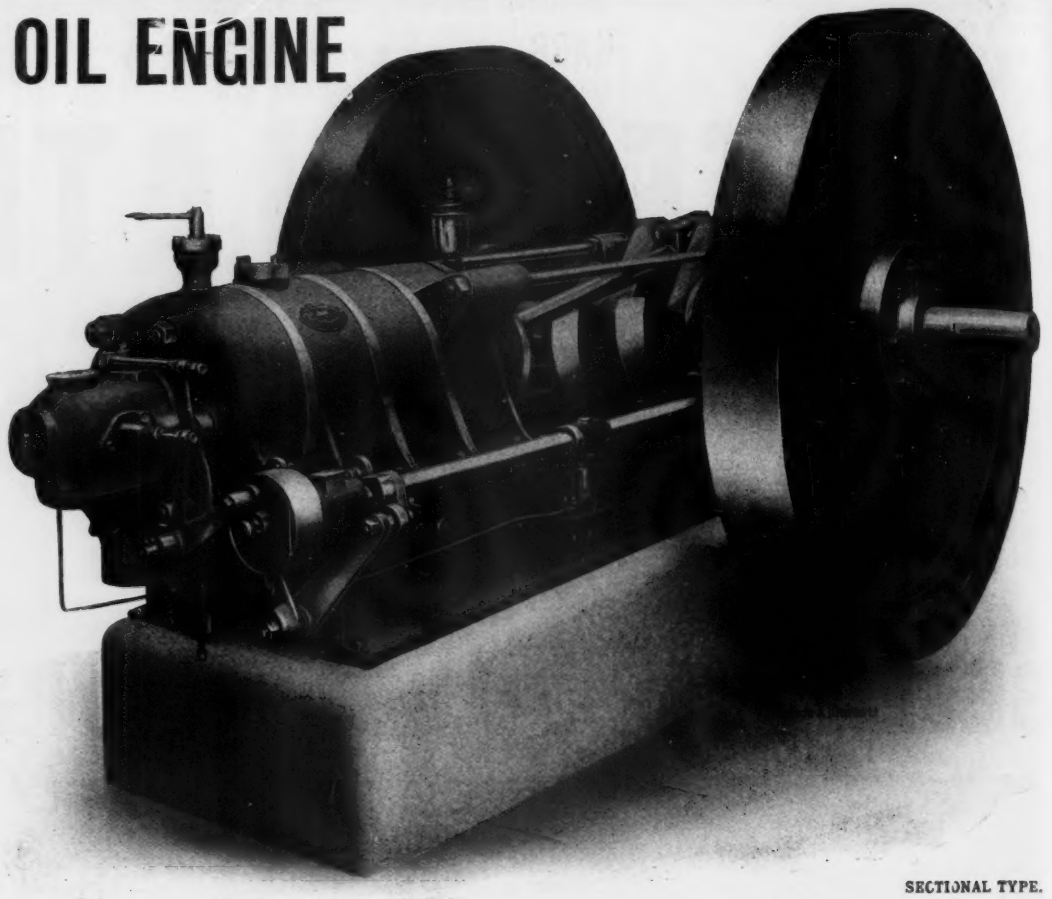
This is from a photograph of the Sectional Oil Engine. The Fly Wheels and other parts that are heavy in the ordinary Engines are built in sections for the convenience of transport. A19:2



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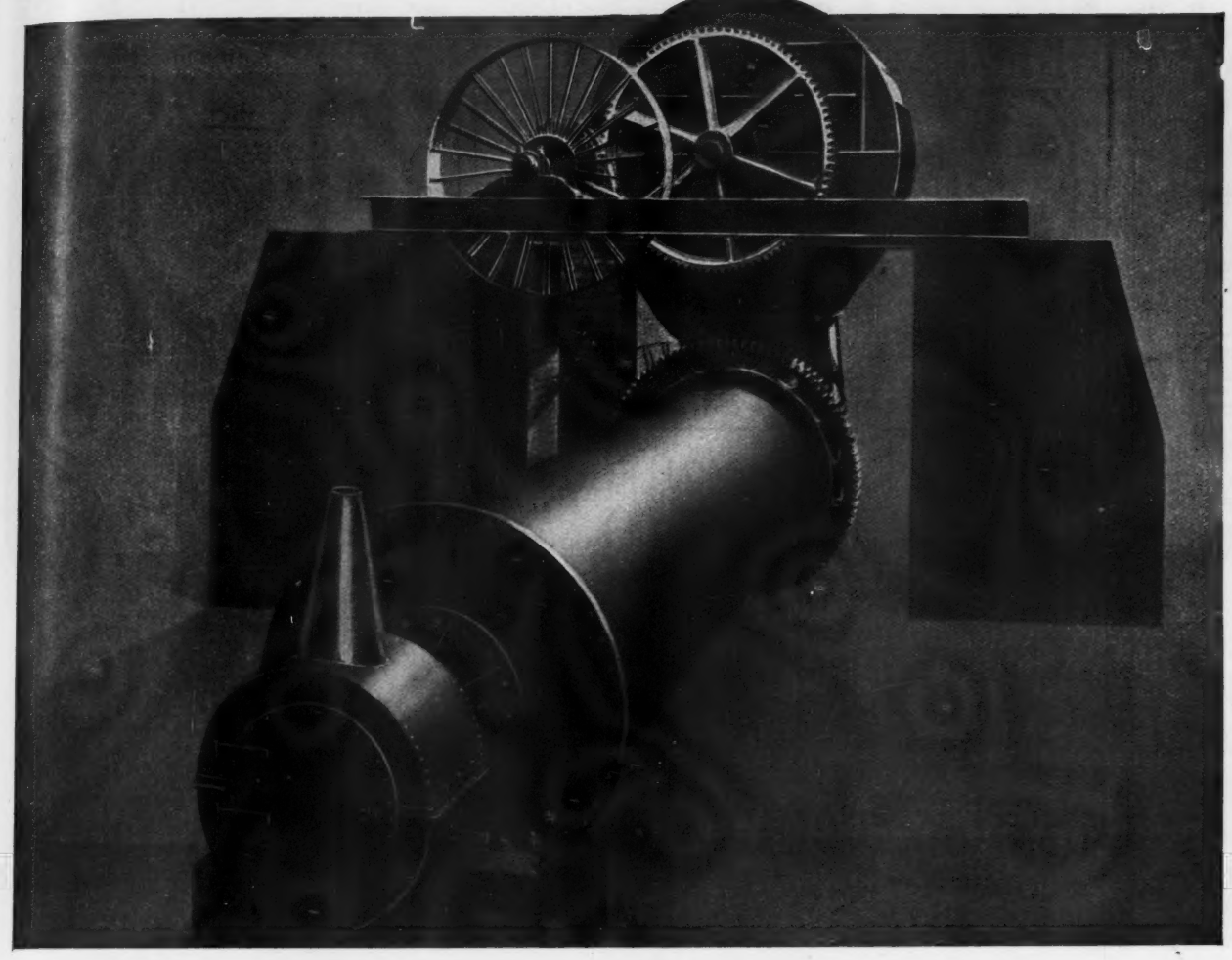

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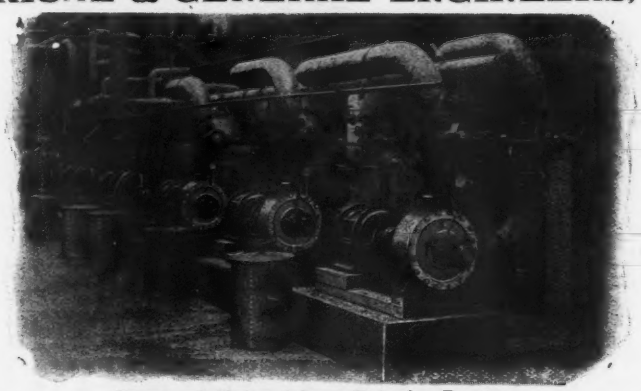

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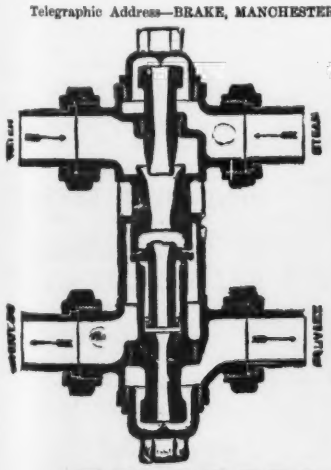

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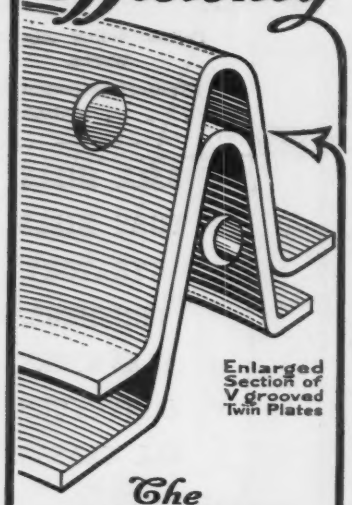

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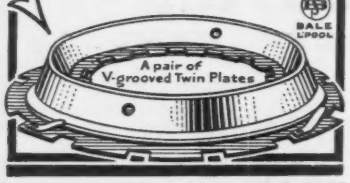

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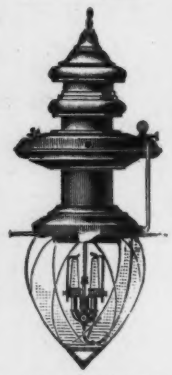

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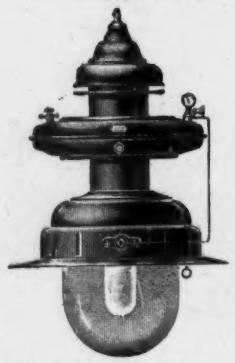

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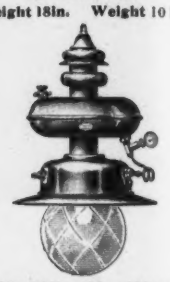
Reservoir-Lamp, delivery by Parcel Post.
Height 18in. Weight 10 lb.



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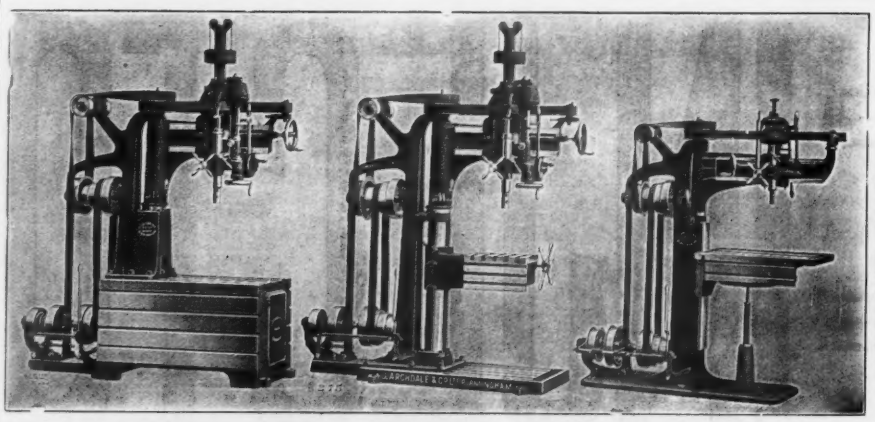

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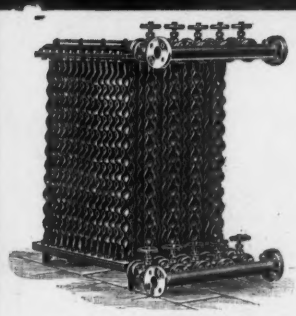

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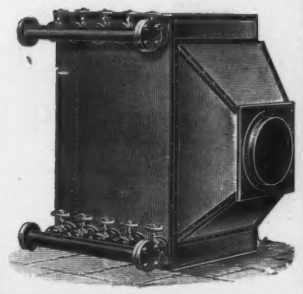

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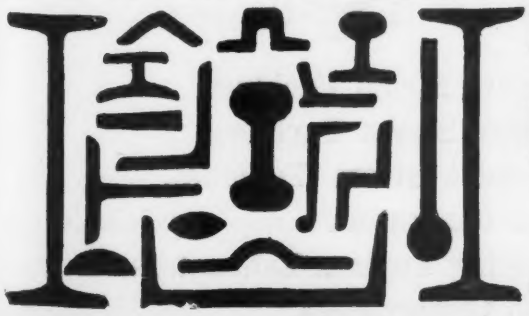

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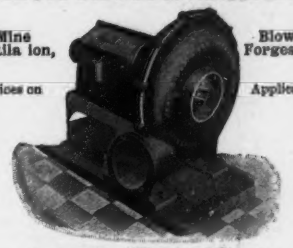

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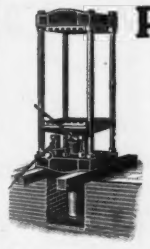

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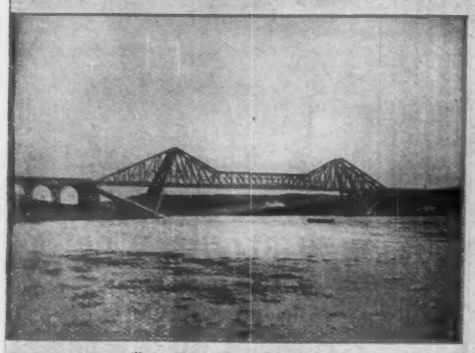

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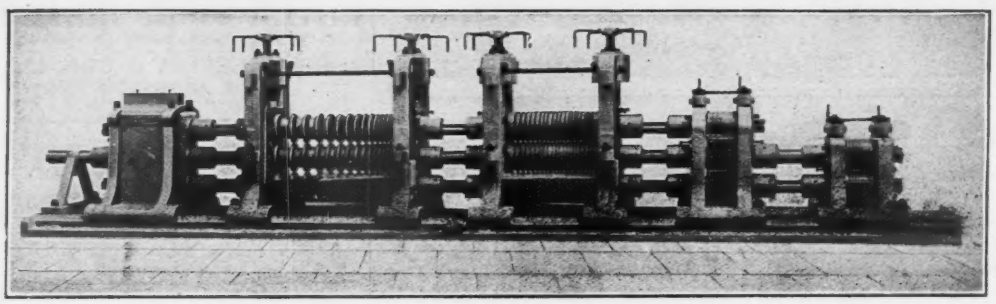

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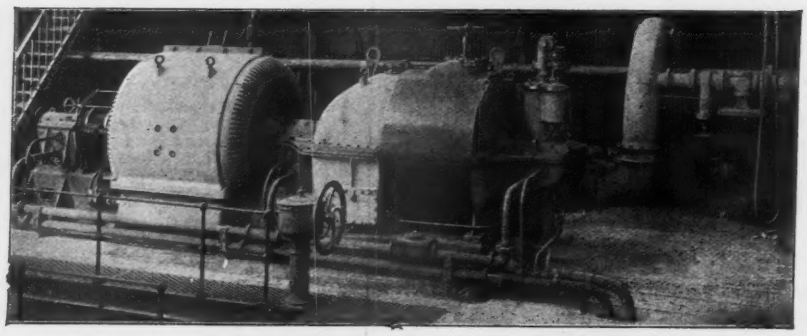

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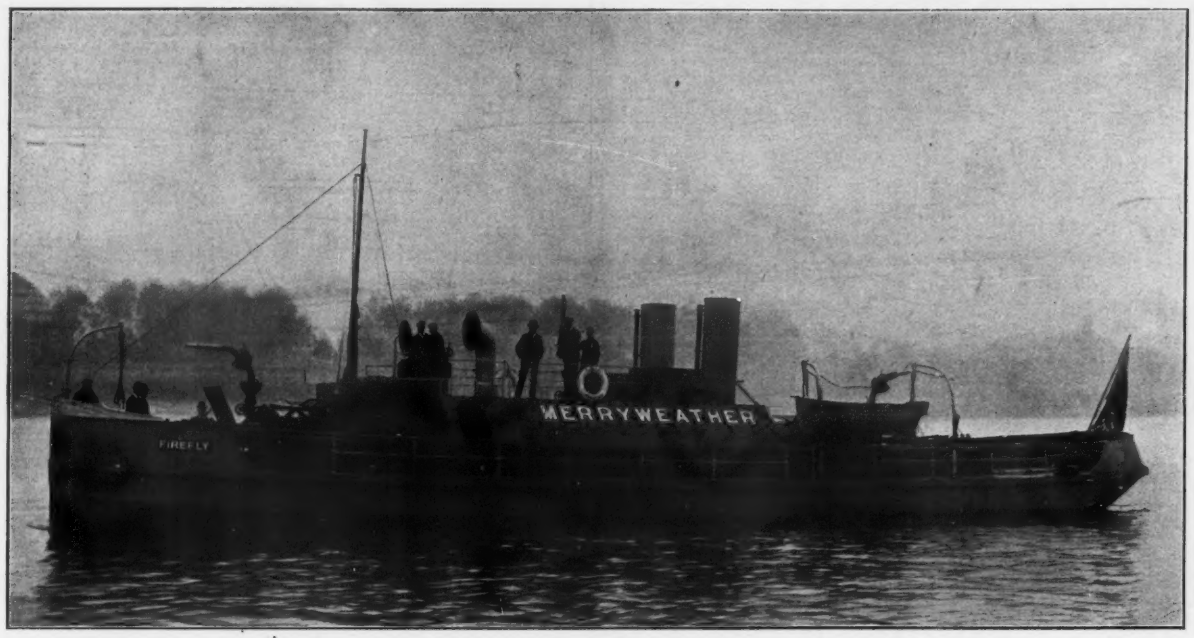

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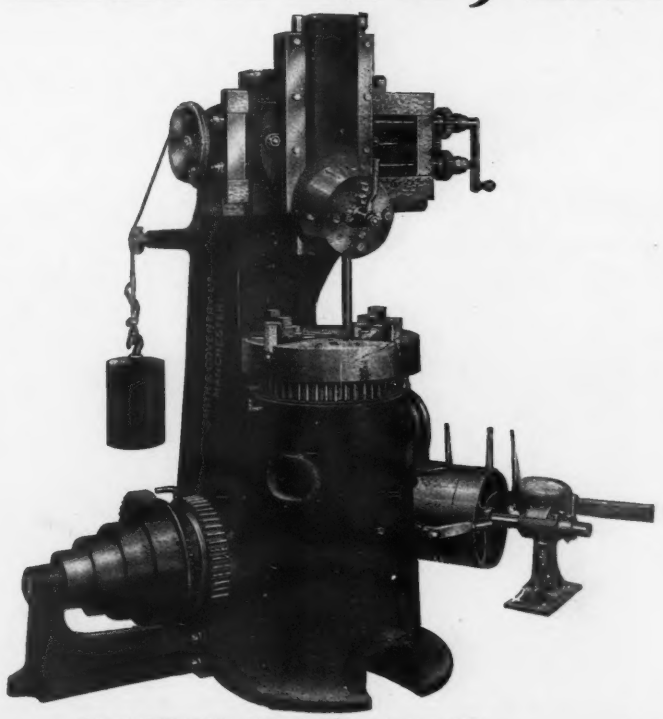

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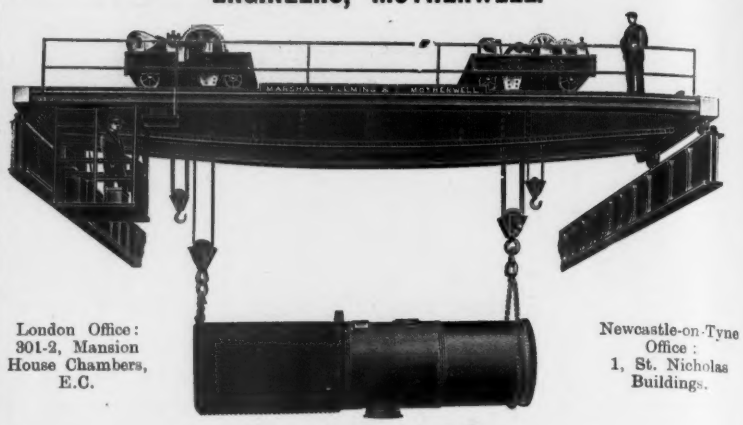

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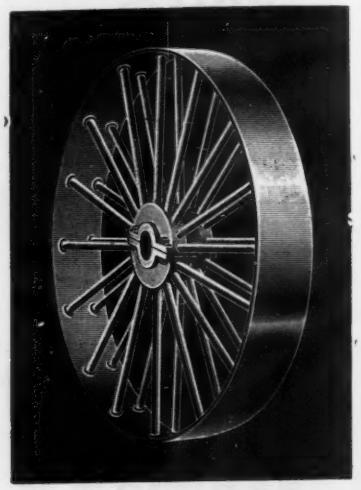

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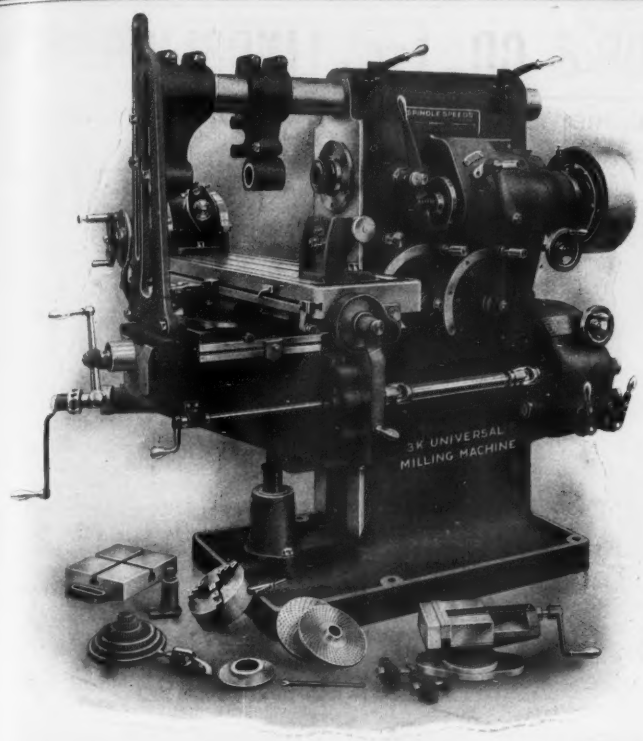

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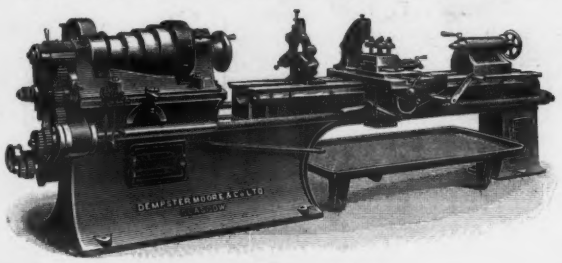

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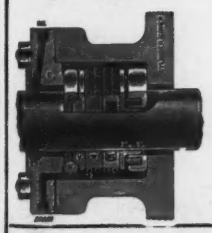

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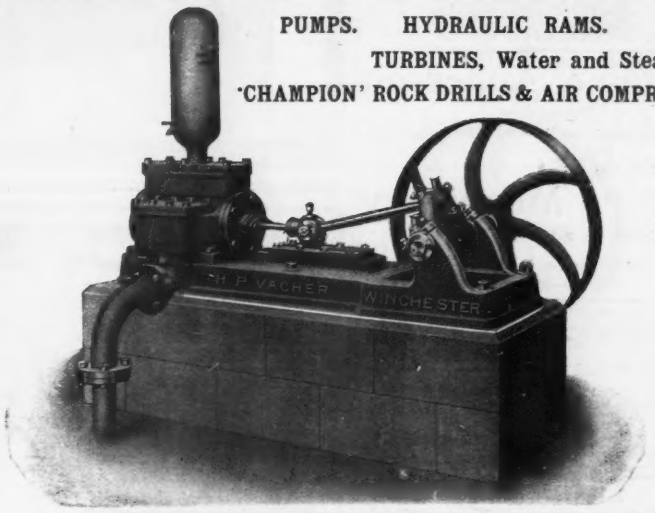

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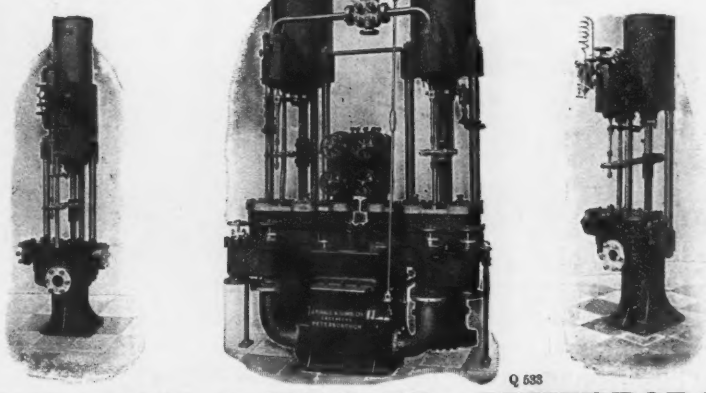

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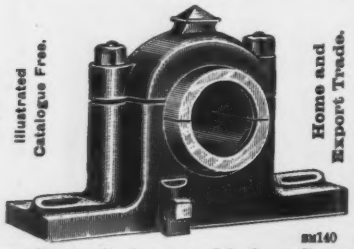

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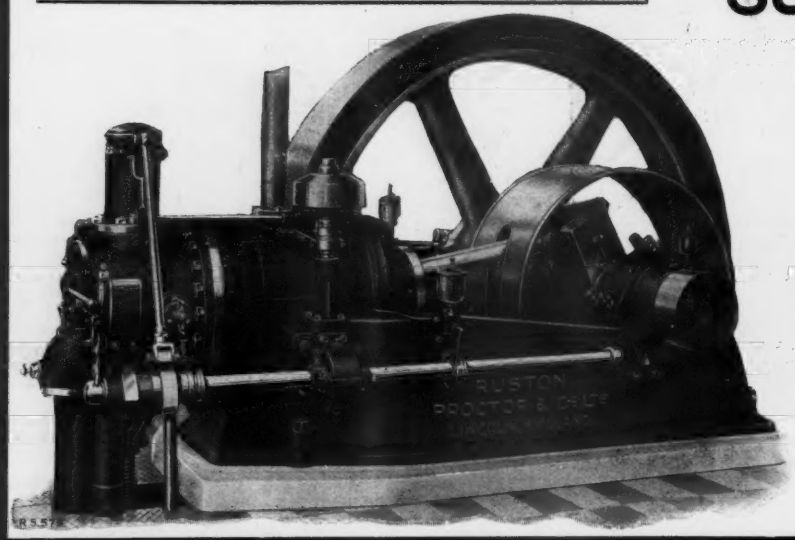

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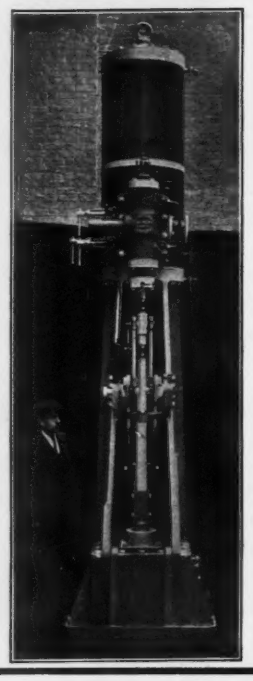

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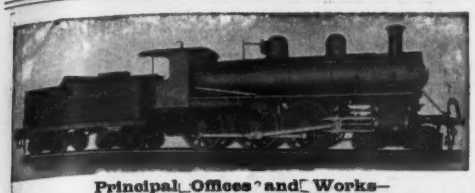

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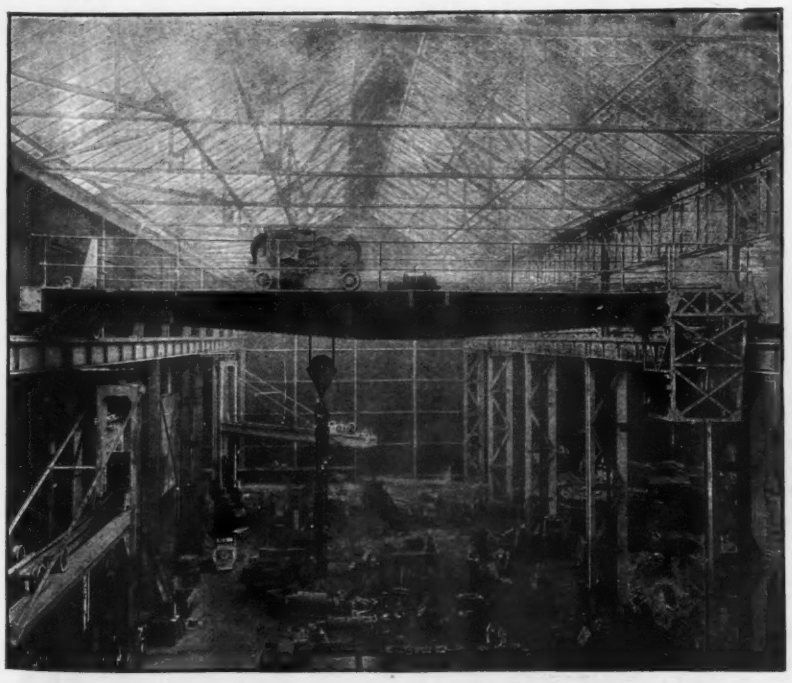

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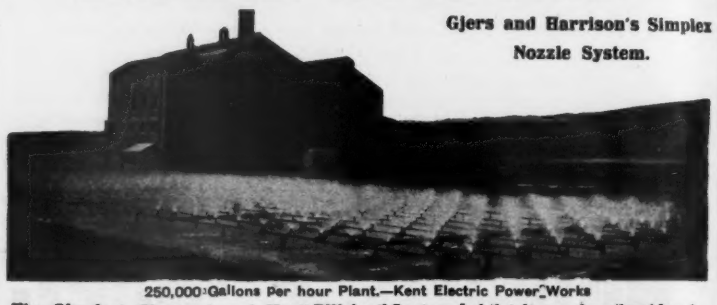

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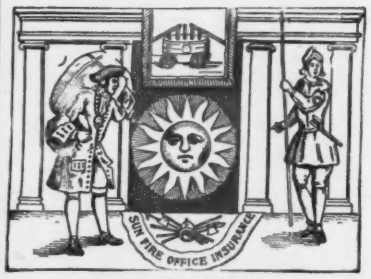

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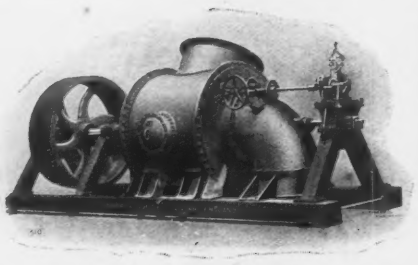

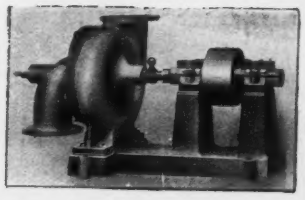

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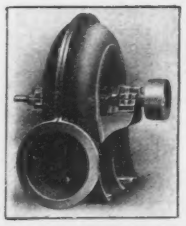

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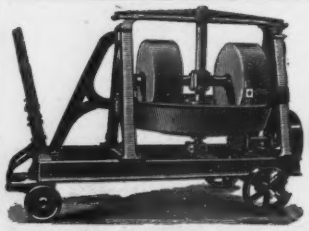

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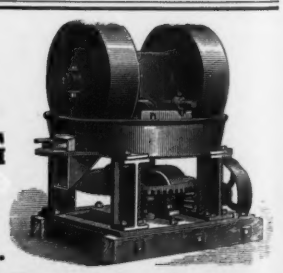

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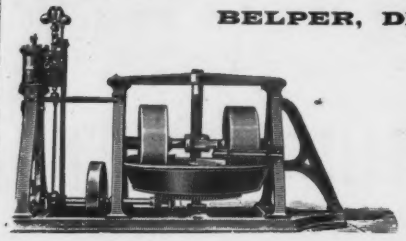

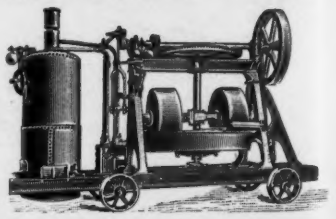

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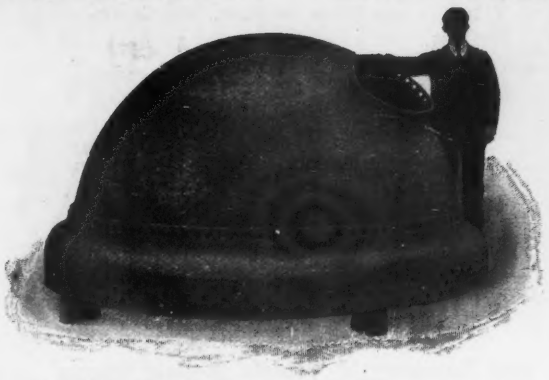

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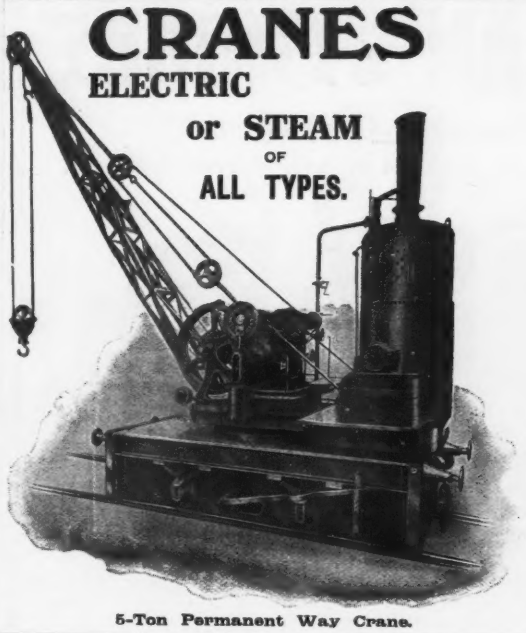

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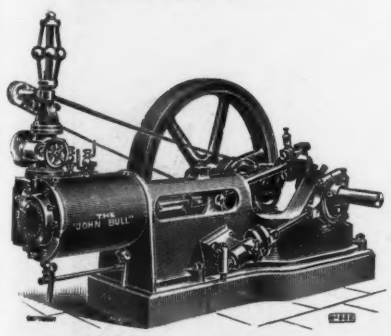

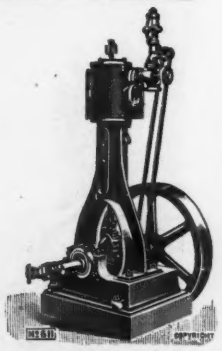

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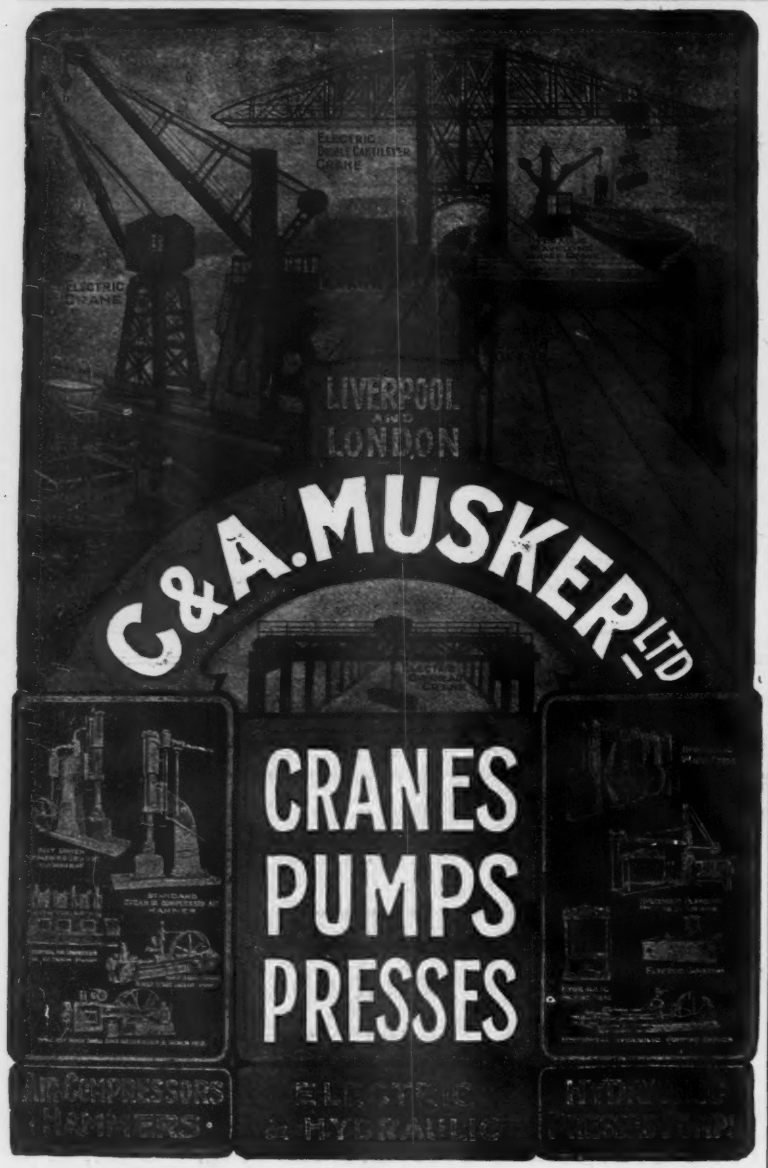

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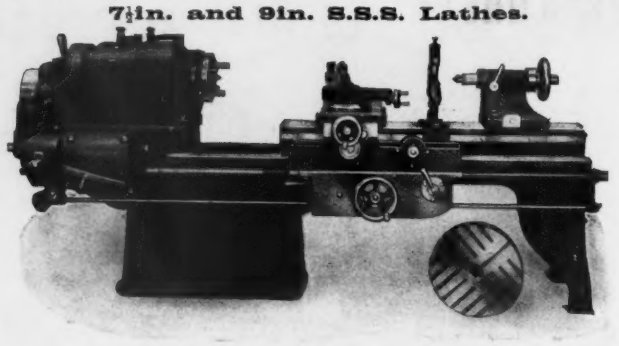

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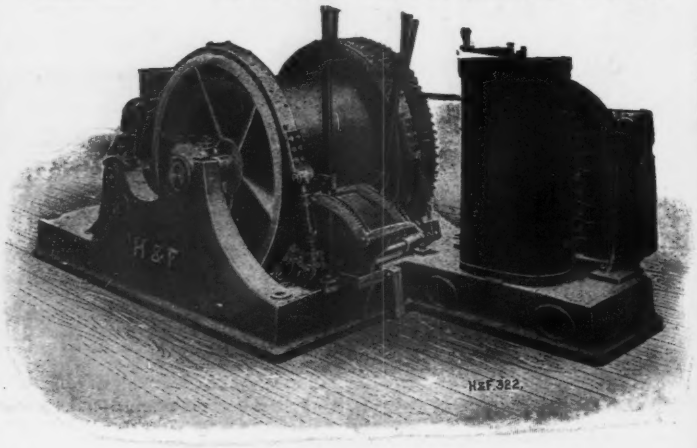

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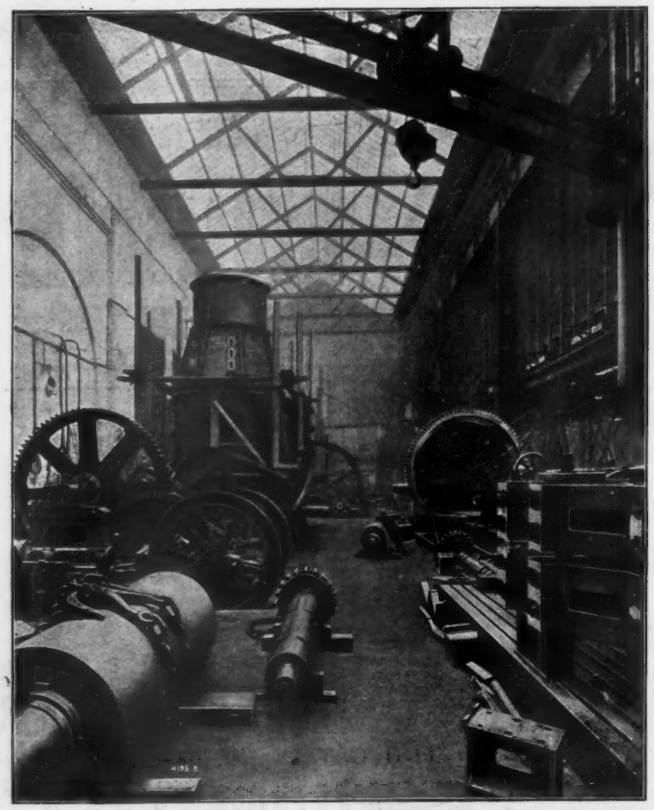

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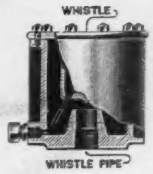

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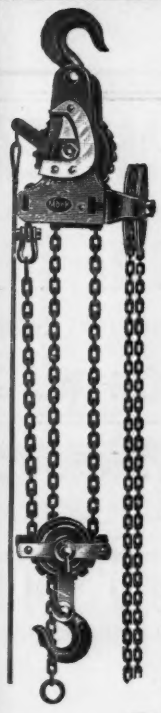

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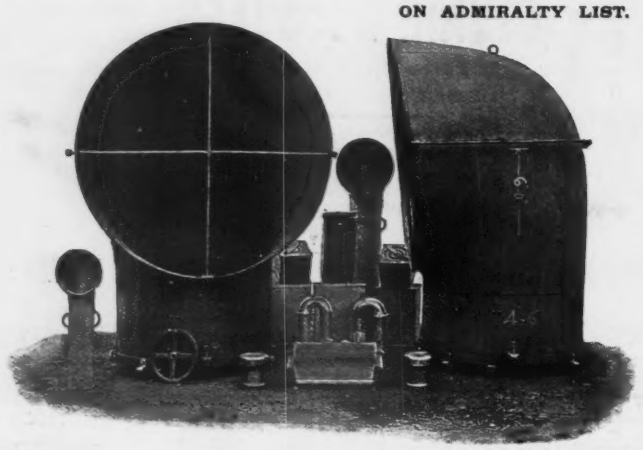

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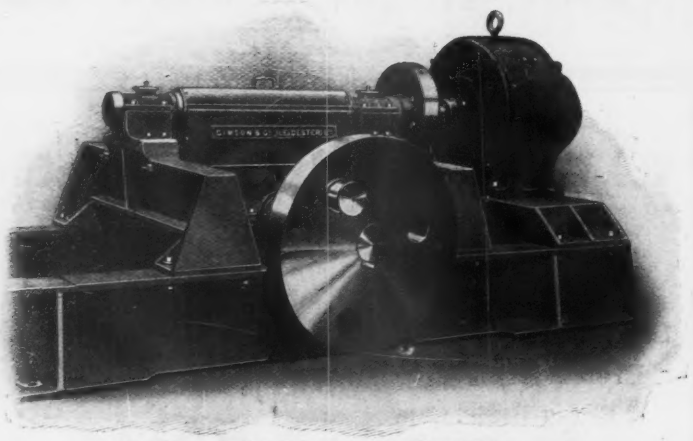

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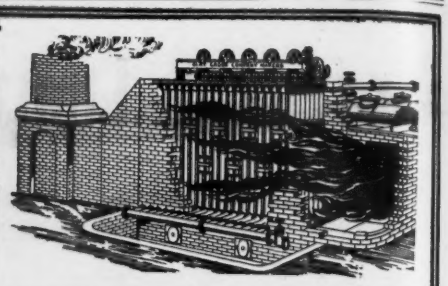

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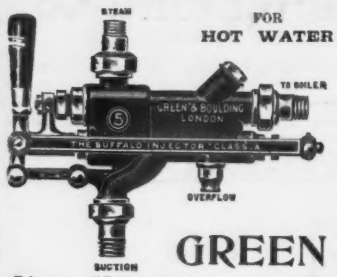

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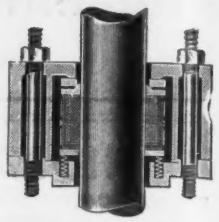

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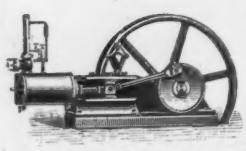

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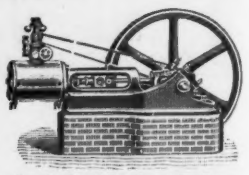

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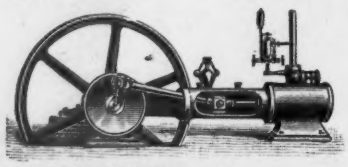

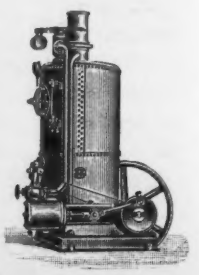

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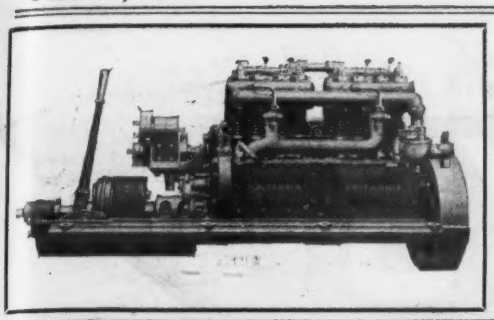

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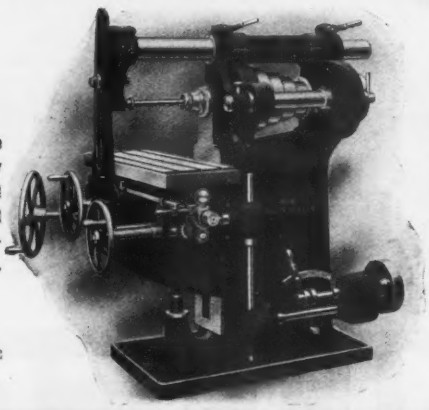

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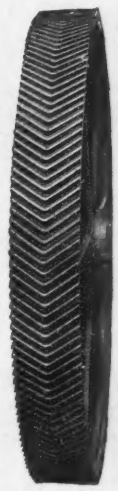

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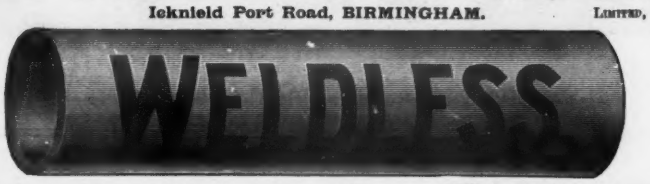

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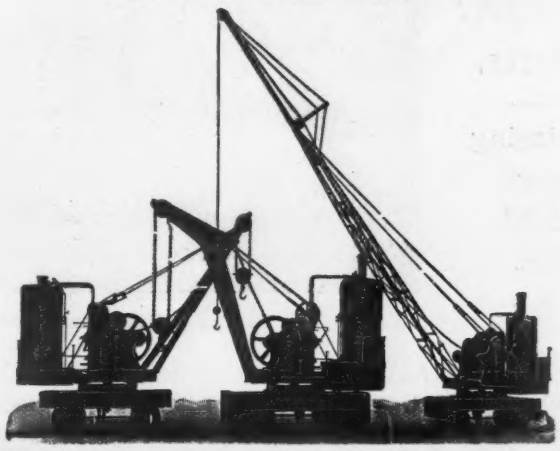

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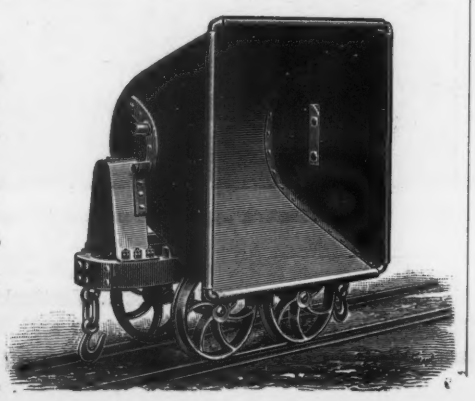

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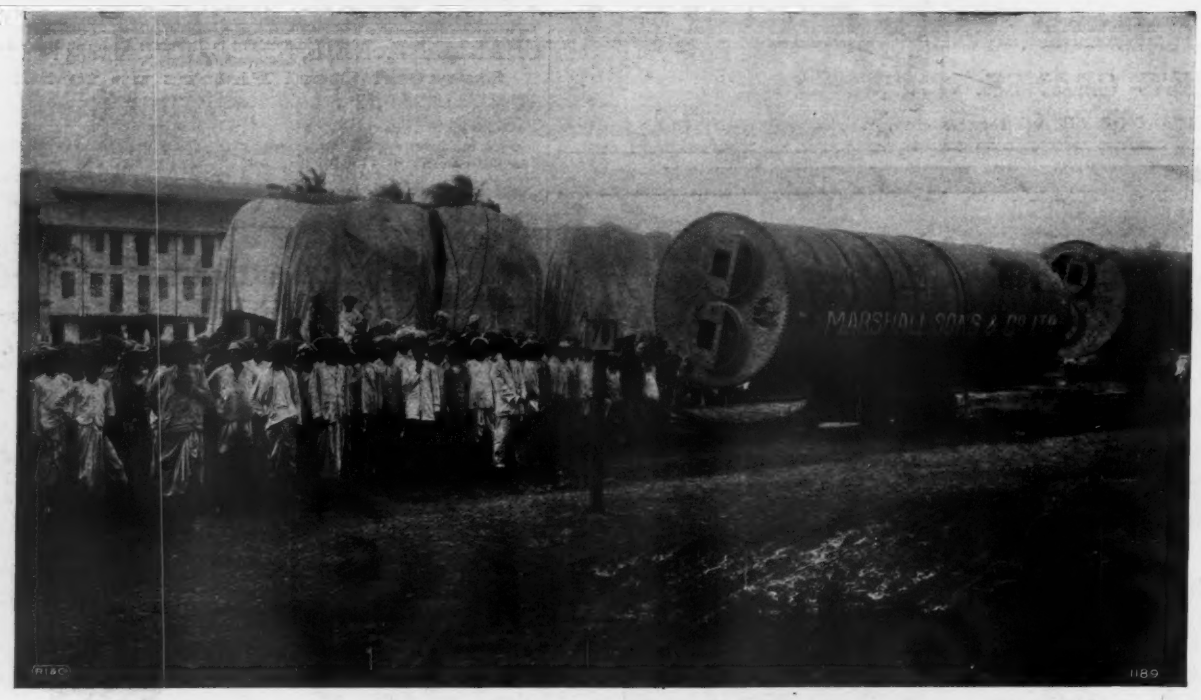

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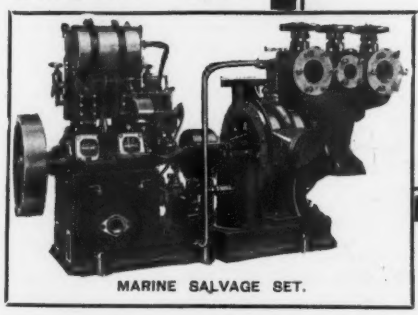
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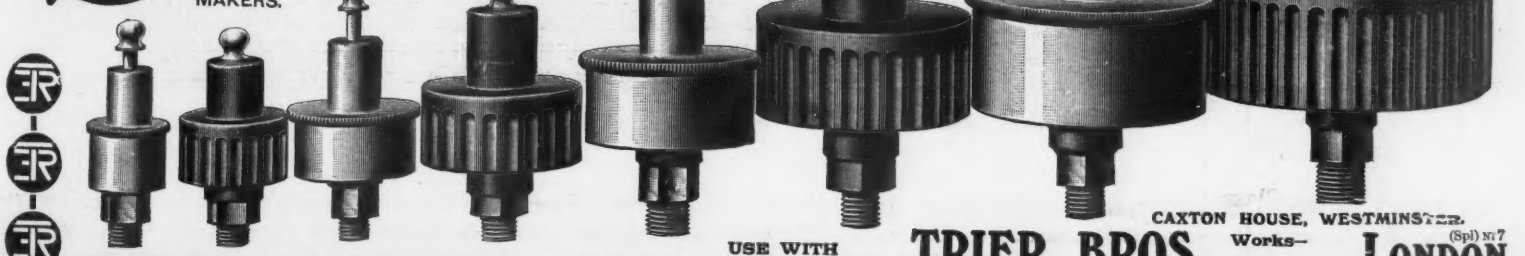

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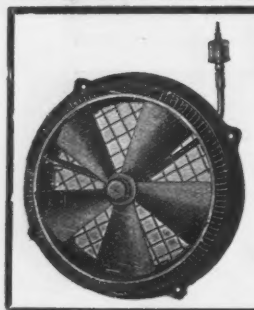

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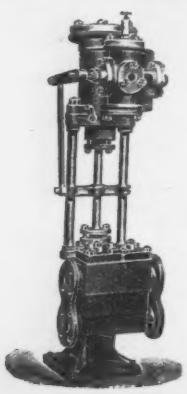

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Royles Limited
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Wheeler Condenser Co
Willans and Robinson, Ld

Conveyor Belts
Gandy Belt Manufactur'g Co
Reddaway, F., and Co. Ld

Conveyors
Bagshawe and Co., Ld
Chain Belt Engineering Co
Conveyor and Elevator Co
Gilbert Little Co., Ld
Head, Wrightson and Co., Ld
Heenan and Froude, Ld
Leech, Goodall and Co
Lidgerwood Mfg. Co
New Conveyor Co., Ld
Rubery, Owen and Co
Simon-Carves, Ld

Cooling Towers
Balcke and Co
Midland Engineering Co

Cotton Driving Ropes
Kenyon, W., and Sons, Ld

Couplers, Automatic
Laycock, W. S., Ld

Cranes
Arrol, Sir W., and Co., Ld
Bedford Engineering Co
Berry, H., and Co., Ld
Booth, Jos., & Bros. (Rodley)
Broadbent, T., and Sons
Butters Bros. and Co
Chaplin, A., and Co
Coles, H. J., Ld
Cowans, Sheldon and Co., Ld
Craven Brothers, Ld
Fielding and Platt, Ld
Gibbins, R. C., and Co
Grafton and Co., Ld
Grieve, J., and Co
Henderson, J. M., and Co
Heywood, S. H., and Co. Ld
Isles, Ld
Jack, A., and Co
Leeds Eng'g & Hydraulic Co
Marshall, Fleming and Co
Mitchell-Williams Crane Co
Morgan, W., and Co
Musker, C. and A., Ld
Ransomes and Rapier, Ld
Royce Ld
Russell, G., and Co
Smith, John (Keighley), Ld
Smith, T., and Sons (Rodley)
Taylor and Hubbard
Vaughan and Son, Ld
Whitaker Bros, Ld
Wilson, J. H., and Co., Ld
Zobel, Neubert and Co

Cupolas
Davies, T., and Son

Cutting Compound
Cowens, J., and Co

Destructors
Horsfall Destructor Co., Ld

Diving Apparatus
Barnett and Foster
Siebe, Gorman and Co., Ld

Dog Spikes
Clyde Nail Co., Ld

Drawing Apparatus
Davis, J., and Son, Ld

Drawings and Tracings
Thorp, J. B.

Dredge Plant
Ferguson Brothers
Fleming and Ferguson, Ld
Gwynnes Limited
Lobnitz and Co., Ld
Priestman Bros., Ld
Simons, W., and Co., Ld
Smulders, A. F.

Drop Forgings and Stampings
Armstrong, Stevens and Son
Brett's Stamping Co., Ld
Brooks, J. B., and Co
Horton and Son, Ld

Drop Hammers
Brett's Patent Lifter Co., Ld
Ross, R. G., and Son, Ld

Dynamometers
Heenan and Froude, Ld

Electricity
Brit. Westinghouse Electric Co
Clarke, Chapman and Co., Ld
Crompton and Co., Ld
Dick, Kerr and Co., Ld
Electromotors Ld
Ferranti Limited
Fowler, J., and Co., Ld
Hall J. P., and Co
Hartnell, W., and Co., Ld
India-rubber, Gutta-percha, & Telegraph Works Co., Ld
Laurence, Scott and Co., Ld
Mather and Platt, Ld
Phillips, J. W. and C. J.
Phœnix Dynamo Co., Ld
Rees Roturbo Mfg. Co., Ld
Reyrolle and Co., Ld
Royce Limited
Scott and Mountain, Ld
Siemens Bros. Dynamo Works

Electric Welding
British Insulated and Helsby Cables, Ld

Elevators
Chain Belt Engineering Co
Conveyor and Elevator Co
East Ferry Road Eng'g Co
Heenan and Froude, Ld
Leech, Goodall and Co
Newell, E., and Co., Ld

Emery, Emery Wheels, &c.
Carborundum Co
Davies, W. J., and Sons
London Emery Works Co
Luke and Spencer, Ld
Mayer and Schmidt
Mitchell's Emery Wheel Co
Oakey, J., and Sons
Sterne, L., and Co., Ld

Engine & Boiler Fittings, &c.
Bell's United Asbestos Co., Ld
Hopkinson, J., and Co., Ld
Hulburd Engineering Co
Klinger, R., and Co
Schaffer and Budenberg, Ld

Engineers' Studs
Beebee, A.

Evaporators
Blair, Campbell and McLean
Davie and Horne
Liverpool Engineering and Condenser Co., Ld
Weir, G. and J., Ld

Excavators
Priestman Bros., Ld
Wilson, J. H., and Co., Ld

Explosives
Curtis's & Harvey, Ld

Fans & Turbines
Allen, W. H., Son and Co., Ld
Buffalo Forge Co
Bumsted and Chandler, Ld
Davidson and Co., Ld
Gibbs, John, and Sons
Gilkes, G., and Co., Ld
Gunther, W., and Sons
Keith and Blackman Co., Ld
Parsons, C. A., and Co
Pitman, Perer
Russell, S., and Sons
Sturtevant Engineering Co
Thwaites Brothers, Ld
Waddle Patent Fan and Engineering Co

Feed-water Heaters
Caird and Rayner
Davie and Horne
Holden and Brooke, Ld
Royles Limited
Wheeler Condenser and Engineering Co
Wright, Jos., and Co

Filters, Waste Oil
Wells, A. C., and Co

Flexible Couplings
Croft and Perkins, Ld

Flour Mill Engineers
Turner, E. R. and F.

Forced Draught
Howden, J., and Co

Forgings
Brown, J., and Co., Ld
Cammell, Laird and Co., Ld
Darlington Forge Co., Ld
Firth, T., and Sons, Ld
Grantham Boiler and Crank Co
Ince Forge Co., Ld
Mills, Exors. of J.
Rotherham F. rge Co., Ld
Walker Bros., Ld., Wigan

Friction Clutches
British Hele-Shaw Clutch Co
Coil Clutch Co., Ld
Croft and Perkins, Ld
Edmeston, A., and Sons, Ld
Kay, J. C., and Co., Ld
Saver Clutch Co., Ld
Unbreakable Pulley and Mill Gearing Co., Ld
Wigglesworth, F., and Co., Ld

Fuel Economisers
Clay Cross Co
Green. E., and Son
Schulz, M. R., Ld

Furnace Bars
Miller and Co., Ld

Furnaces
Burdon, J., and Sons
Dowson and Mason Gas Plant Co., Ld
Fraser and Chalmers, Ld
Leeds Forge Co., Ld
Meldrum Bros., Ld

Fusible Plugs
Bailey, W. H., and Co., Ld
National Boiler and General Insurance Co

Galvanising Plant
Butterfield, W. F., Ld
Lysaght, J., Ld

Gas
British Hydrogen Co
Dowson & Mason Gas Plant Co

Gas Engines
British Westinghouse Electric and Manufacturing Co., Ld
Crossley Brothers, Ld
Davey, Paxman and Co., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons, Ld
Grice's Gas Engine Co., Ld
Hornsby, R., and Sons, Ld
National Gas Engine Co., Ld
Premier Gas Engine Co., Ld
Ruston, Proctor and Co., Ld
Tangyes Limited
Williams, H. W.

Gauge Glasses
Butterworth Bros., Ld
Guilbert-Martin
Hopkinson, J., and Co., Ld
Moncrieff, J., Ld
Tomey, J., and Sons, Ld

Gauge Glass Protectors
Hulburd Engineering Co
Tomey and Sons, Ld

Gauges
Crosby Steam Gage & Valve Co
Crown Works, Chelmsford
Klinger, R., and Co
Negretti and Zambra
Newall Engineering Co
Schaffer and Budenberg, Ld
Thermo and Pressure Instruments, Ld
Tomey and Sons, Ld

Gear Cutting
Barlow and Chidlaw Ld
Brown, D., and Sons, Ld
Northern Manufact'g Co., Ld

Gearing
Bodley Brothers and Co
Brown, D., and Sons, Ld
Citroen, A., and Co
Harpers Limited
Jackson, P. R., and Co., Ld
Reid Gear Co
Unbreakable Pulley Co., Ld
Wigglesworth, F., and Co

Governors
Boving, J. Orten, and Co
Monovel Governor Co
Pollock, Macnab and Highgate

Grinding Machinery
Bradley Pulveriser Co
Mayer and Schmidt
Mitchell's Emery Wheel Co
Smedley Bros., Ld

Hammers
Davis and Primrose
Dunlop, J.
Massey, B. and S.
Perry, T., and Son, Ld
Pilkington, P., Ld
Player, W. and J.
Pollock, Macnab and Highgate
Ross, R. G., and Son
Samuelson and Co., Ld
Thwaites Brothers, Ld

Handles
Burley and Son, Ld

Harbour Plant
Stothert and Pitt, Ld
Wilson, John H., and Co., Ld

Haulage Gear
Clarke, Chapman and Co., Ld
Grant, Ritchie and Co
Heenan and Froude, Ld

Heating Apparatus
Browning, W. E., and Co., Ld
Buffalo Forge Co
Körting Brothers, Ld

Hose
Merryweather and Sons, Ld
Reddaway, F., and Co., Ld

Hydraulic Machinery
Adlam, G., and Sons, Ld
Arrol, Sir W., and Co., Ld
Berry, H., and Co., Ld
Fielding and Platt, Ld
Holt and Willetts
Leeds Eng'ng & Hydraulic Co
Musgrave Bros.
Musker, C. and A., Ld
Rice and Co., Ld
Shaw, John, and Sons, Ld
Smith, Hugh, and Co
Stewart, D., and Co., Ld
Vacher, H. P.
Youngs

Hydro-extractors
Broadbent, T., and Sons, Ld

Ice Machinery (*see* Refrigerating Mach'y)

Igniter, Gas and Oil Engine
Lodge Bros. and Co

India-rubber, &c.
Dunlop Rubber Co., Ld
India-rubber, Gutta-percha, & Telegraph Works Co., Ld
Reddaway, F., and Co., Ld

Injectors & Ejectors
Davies and Metcalfe, Ld
Green and Boulding, Ld
Gresham and Craven, Ld
Holden and Brooke, Ld
Klinger, R., and Co
Wilcox, W. H., and Co., Ld

Insurance
Sun Insurance Office

Iron and Steel Works Plant
Brown, J., and Co., Ld
Davy Bros., Ld
Dewhurst Engineer'g Co., Ld
Jones, George, Ld
Perry, T., and Son, Ld
Stevensons, Preston

Iron and Steel Buildings & Roofs
Ash, J., and Son
Bagshaw, J., and Sons, Ld
Beanlis, E., and Co., Ld
Boulton and Paul, Ld
Braby, F., and Co
Brownlie and Murray, Ld
Bruce and Still, Ld
Clayton, Son and Co., Ld
Cleveland Bridge & Eng'g Co
Clyde Structural Iron Co., Ld
Grover and Co., Ld
Lysaght, J., Ld
Main, A. and J., and Co
Meehan and Sons, Ld
Piggott, T., and Co., Ld
Walker Brothers, Ld

Jointing
Graphite Products, Ld
Hudson, J., and Co., Success's
Jenkins Bros., Ld
Klinger, R., and Co
Walker, J., and Co

Lantern Slides
Fry, E. B.

Laundry Machinery
Summerscales Limited
Tullis, D. and J., Ld

Lead Machinery
Krupp Grusonwerk, F.
Phillips, J., and Co

Leatherite
Northern Rubber Co

Lifts and Hoists
Gimson and Co., Ld
Holt and Willetts
Waygood, R., and Co. Ld
Youngs

Light
Continental-Light Frankfort
Ulmann and Co., Ld
Wakefield, C. C., and Co
Wells, A. C., and Co

Locks
Kaye, J., and Sons, Ld

Locomotives
American Locomotive Co
Avonside Engine Co., Ld
Bagnall, W. G., Ld
Baldwin Locomotive Works
Beyer, Peacock and Co., Ld
British Humboldt Eng. Co
Davies and Metcalfe, Ld
Green, T., & Sons, Ld
Hawthorn, Leslie and Co., Ld
Hudswell, Clarke and Co
Hunslet Engine Co., Ld
Kerr, Stuart and Co., Ld
Nasmyth, Wilson and Co., Ld
North British Loco. Co., Ld
Peckett and Sons
Société Anonyme de Saint Léonard
Stephenson, R., and Co., Ld
Vulcan Locomotive Works, Wolf, R.

Lubricators
Steam Cylinder Lubricator Co
Trier Bros.
Wakefield, C. C., and Co

Machine Tools
Archdale, J., and Co
Asquith, W., Ld
Bennie, J., and Son
Berry, F., and Sons, Ld
Berry, H., and Co., Ld
Birch, C., and Co
Britannia Engin'ring Co., Ld
Buck and Hickman, Ld
Buckton, J., and Co., Ld
Burton, Griffiths and Co
Butler, J., and Co
Cameron, J., Ld
Carron Company
Carter and Wright
Chambers, Scott and Co
Clifton and Baird
Clifton and Waddell
Craven Bros., Ld
Cunliffe and Croom, Ld
Daniell, S. A., Ld
Darling and Sellers, Ld
Davis and Primrose
Dean, Smith and Grace, Ld
De Bergue and Co., Ld
Dempster, Moore and Co., Ld
Dron and Lawson, Ld
Drummond Bros., Ld
Goodchild, G. W., & Partner
Harvey, G. and A.
Heap, J., and Co., Ld
Herbert, A., Ld
Hetherington, J., & Sons, Ld
Hill, Isaac, and Son
Hulse and Co., Ld
Greenwood and Batley, Ld
Judson-Jackson Company
Jones and Lamson Machine Co
Kearns, H. W., and Co., Ld
Kendall and Gent, Ld
Lang, J., and Sons
Lodge & Shipley M'e. Tool Co
Loudon Bros., Ld
Maclellan, P. and W., Ld
McGown, Rogers, and Co
McKendrick, W. D., and Co
Midgley and Sutcliffe
Muir, W., and Co
Noble and Lund, Ld
Parkinson, J., and Son
Pearn, F., and Co., Ld
Pfeil and Co
Platt, S., Ld
Pollock and McNab, Ld
Redman, C., and Sons
Reinecker, J. E.
Rice and Co., Ld
Richards, G., and Co
Ryder, T., and Son
Schuchardt and Schutte
Searle, W., and Co
Shanks, T., and Co
Smith and Coventry, Ld
Smith, G. F., Ld
Smith, Hugh, and Co., Ld
Spencer, J., and Co
Stirk, J., and Sons
Storey, J. H., and Co
Tangyes Limited
Tullis, D. and J., Ld.
U.S. Metallic Packing Co., Ld
Vickers Limited
Ward, H. W., and Co
Ward, T. W., Ld
Webster and Bennett, Ld
Wilkinson, G., and Sons

Machine Work
Chesney Engineering Co., Ld
Hooker, Peter, Ld
Phillips, J., and Co
Rosser and Russell, Ld
Wailes, G. and Co

Malleable Castings
Ley's Malleable Castings Co

Manganese Steel Castings & Forg'gs
Allen, E., and Co., Ld
Firth, T., and Sons, Ld
Hadfield's Steel Foundry Co
Osborn, S., and Co., Ld

Manholes
M'Neil, C.
Rolled Steel Forge Co., Ld

Marine Machinery
Broadfoot, J., and Sons, Ld

Mathematical Instruments
Negretti and Zambra
Stanley, W. F., and Co., Ld

Measur'g Machines
Newall Engineering Co

Merchant Iron
Dunkerley, C. C., and Co., Ld
Farnley Iron Co., Ld
Henderson and Glass
Measures Brothers, Ld

Metals
Almagam Limited
Atlas Metal and Alloys Co., Ld
Bull's Metal & Melloid Co., Ld
Delta Metal Co., Ld
Electric and Ordnance Accessories Co., Ld
Johnson, Clapham and Morris
Magnolia Anti-Friction Metal Co. of Great Britain, Ld
Phosphor Bronze Co., Ld
Tandem Smelting Syndicate

Meters
Glenfield and Kennedy, Ld
Lea Recorder Co

Mica
Wiggins, F., and Sons

Mining Machinery
Brit. Humboldt Eng. Co., Ld
Davey, Paxman and Co., Ld
Fraser and Chalmers, Ld
Krupp Grusonwerk, F.
Ransomes, Sims and Jefferies
Robey and Co., Ld
Sandycroft Foundry Co., Ld
Sturtevant Engineering Co
Walker Brothers, Wigan

Motors
Bergius Launch & Engine Co
Electromotors Ld
Phœnix Dynamo Mfg. Co., Ld

Motor Cars:
Drewry Car Co., Ld
Mann's Patent Wagon Co
Thornycroft, J. I., and Co., Ld

Moulding Machines
Greenwood and Batley, Ld
London Emery Works Co
Samuelson and Co., Ld

Oil Engines
Blackstone and Co., Ld
Britannia Engineering Co
Crossley Brothers, Ld
Diesel Engine Co., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons
Hornsby and Sons, Ld
Mirrlees, Bickerton & Day, Ld
Normand, A., Ld
Reavell and Co., Ld
Sharer and Young, Ld
Wilson, A.

Oil Pumps
British Manzel Oil Pump Co

Oil Separators
Baker Oil Separator Co., Ld
Balcke and Co., Ld
Garner, Telford and Hardman
Holden and Brooke, Ld
Kater and Ankersmit
Paterson Engineering Co., Ld
Rowland, B. R., and Co., Ld

Oil-gas Apparatus
Mansfield and Sons, Ld

Oil Mill Machinery
Rose, Downs & Thompson, Ld

Oils & Lubricants
Dawson, A. H., and Co
Price's Patent Candle Co
Trier Brothers
Stern Sonneborn Oil Co., Ld
Wakefield, C. C., and Co

Oil Well Drills
Oil Well Supply Co

Overhead Runways
Vaughan and Son, Ld

Packing, Metallic:
Green and Boulding, Ld
Hobdell, Way and Co., Ld
Hudson, J., & Co., Successors
Hulburd Engineering Co
Klinger, R., and Co
Lancaster and Tonge, Ld
Titan Packing Co
U.K. Metallic Packing Synd
U.S. Metallic Packing Co., Ld
Walker, J., and Co

Paint for Steel Work
Dampney, J., and Co

Painting Machines
Wells, A. C., and Co

Patent Agents
Alexander, E. P., and Son
Harris and Mills
Jensen and Son
King's Patent Agency
Lloyd Wise and Co
Redfern, G. F., and Co
Roots, J. D.
Sokal, S.
Vaughan and Son
Withers, J. S., and Spooner

Pattern Makers
Brown, D., and Sons, Ld

Pattern Making Machinery
Wadkin and Co

Perforated Metals
Barns. W. and Son

Photo Printing
Halden, J., and Co., Ld
Hall, B. J., and Co., Ld

Pig Iron
Clay Cross Co
Lilleshall Co

Pile Drivers
Nasmyth, Wilson and Co., Ld

Pipes, Iron & Steel
British Welding Co., Ld
Dempster, R. and J.
Meehan and Sons
Metal & Machinery Syndicate
Piggott, T., and Co., Ld
Stewarts and Lloyds, Ld

Pistons
Lancaster and Tonge, Ld
Lockwood and Carlisle, Ld
M'Nell, C., jun.
Standard Piston Ring Co., Ld

Plates, Steel
Colville, D., and Sons, Ld
Glasgow Iron and Steel Co

Plummer Blocks
Jardine, J.
Unbreakable Pulley Co., Ld

Pneumatic Tools
Consolidated Pneumatic Tool Co., Ld
Globe Pneumatic Eng. Co., Ld

Portland Cement
Wouldham Cement Co., Ld

Printing
Reveirs, Geo.

Presses
Berry, H., and Co., Ld
Brett's Patent Lifter Co., Ld
Fawcett, Preston and Co., Ld
Hands, J., and Sons, Ld
Nasmyth, Wilson and Co., Ld
Taylor and Challen, Ld

Pulley Blocks
Godfrey, J. T.
Mork Patent Pulley Block Co
Vaughan and Son, Ld

Pulleys
Douglas, Lawson and Co
Fraser, D., and Sons
Harpers Limited
Hudswell, Clarke and Co., Ld
Jackson, P. R., and Co., Ld
Mork Patent Pulley Block Co
Smith and Grace
Thompson and Southwick, Ld
Unbreakable Pulley Co., Ld
Wigglesworth, F., and Co., Ld

Pumps
Ashton, Frost and Co., Ld
Batchelor, Richd. D.
Boving, J. Orten, and Co
Bracket, F. W., and Co., Ld
Cameron, Ld
Carruthers, J. H., and Co
Cochrane, John
Daniels, T. H. and J., Ld
Drum Engineering Co
Drysdale, J., and Co
Easton and Anderson
Entwisle and Gass, Ld
Evans, J., and Sons
Fleming and Ferguson, Ld
Gimson and Co., Ld
Glenfield and Kennedy, Ld
Gwynnes, Ld
Hall, J. P., & Sons, Peterboro
Hathorn, Davey and Co., Ld
Hayward-Tyler and Co., Ld
Hughes and Lancaster
Lamplough and Son, Ld
Manlove, Alliott and Co., Ld
Merryweather and Sons, Ld
Mills, E., and Son
Mumford, A. G., Ld
Pearn, F., and Co., Ld
Potter, A. C., and Co
Pulsometer Eng'n'ng Co., Ld
Reader, E., and Sons, Ld
Rees Roturbo Mfg. Co., Ld
Richards, E., and Co
Simpson, J., and Co., Ld
Storey, I., and Sons, Ld
Tangyes Limited
Thwaites Bros., Ld
Warner, R., and Co
Weir, G. and J., Ld
Westinghouse Brake Co., Ld
Wilcox, W. H., and Co., Ld
Willans and Robinson, Ld
Worthington Pump Co., Ld

Railway Plant
Allen, Edgar, and Co., Ld
Bagnall, W. G., Ld
Birch, J., and Co., Ld
Bolling and Lowe
British Thomson-Houston Co
Cammell Laird and Co., Ld
Cravens, Limited
Dick, Kerr and Co., Ld
Firth, T., and Sons, Ld
Fowler, J., and Co., Ld
Glasgow Rail and Engin'g Co
Griffith, W., and Sons
Harrison and Camm, Ld
Hudson R.
Isca Foundry Co
Kerr, Stuart and Co., Ld
Koppel, A.
Laycock, W. S., Ld
Leeds Forge Co., Ld
Maclellan, P. and W., Ld
McLachlan, and Co
Midland Railway Carriage Co
Motor Rail & Traincar Co., Ld
Patent Shaft and Axletree Co
Pickering, R. Y., and Co., Ld
Railway & General Eng'g Co
Ransomes and Rapier, Ld
Stableford and Co
Summerson, T., and Sons, Ld
Turner, G. R., Ld
United Electric Car Co., Ld

Rams, Hydraulic
Bailey, W. H., and Co., Ld
Blake, John, Ld
Vacher, H. P.

Reducing Valves
Auld, D., and Son
British Steam Specialities
Royles Limited

Refrigerating Machinery
British Humboldt Eng. Co
Hall, J. and E., Ld
Haslam Foundry and Engineering Co., Ld
Linde British Refrigeration Co
Pulsometer Engineering Co
Sterne, L., and Co., Ld

Rivets
Lyall Brothers

Rock Drills
Daw, A. and Z.
Hardy Patent Pick Co., Ld

Rolls and Rolling Mill Plant
Tennent, R. B., Ld

Roofs (*see* Iron Bldgs.)

Sand Blast Machinery
Tilghman's Sand Blast Co., Ld

Screwing Tackle
Chatwin, T.
Hulse and Co., Ld
Widdowson, J. H.
Williamson, J., and Co., Ld

Sea Water Distillers
Fawcett, Preston and Co., Ld

Separators
Rapid Magnetting Mach. Co

Sewage Plant
Manlove, Alliott and Co., Ld

Shafting
Croft and Perkins, Ld
Fraser, Douglas, & Sons, Ld
Govan Shafting Co
Harpers Limited
Mackies, Ld
Platt, S., Ld

Shearing Machines
Jones, Geo., Ld

Ships' Plumbing Work
Broadfoot, J., and Sons, Ld

Signalling, Power
McKenzie, Holland & Westinghouse Power Signal Co

Small Tools
Chatwin, T.
Vickers Limited

Soap
Sanoper Agency, The

Soda Water Machinery
Barnett and Foster

Springs
Eberle, J. N., and Co
Lion Spring Co
Salter, G., and Co

Steam Engines
Ashton, Frost and Co., Ld
Belliss and Morcom, Ld
Brazil, Straker and Co., Ld
Brit. Westinghouse Electric Co
Burrell, C., and Sons
Clayton and Shuttleworth, Ld
Cole, Marchent and Morley, Ld
Davey, Paxman and Co., Ld
Drysdale and Co., Ld
Easton and Johnson, Ld
Garrett, R., and Sons, Ld
Hatley Engine Co
Howden, J., and Co
Lees, T. and R.
Marshall, Sons and Co., Ld
Murray, Workman & Co., Ld
Plenty and Son, Ld
Reader, E., and Sons, Ld
Reavell and Co., Ld
Richardsons, Westgarth & Co
Robey and Co., Ld
Ruston, Proctor and Co., Ld
Samuelson and Co., Ld
Saxon, G., Ld
Sisson, W., and Co., Ld
Turner, E. R. and F., Ld
Wilson, A.
Yates and Thom, Ld

Steam Heating for Railway Carriages
Westinghouse Brake Co., Ld

Steam Launches
Cochran and Co., Annan, Ld
Fleming and Ferguson, Ld
Lobnitz and Co., Ld
Simons, W., and Co., Ld
Simpson, Strickland and Co
Vosper and Co., Ld
Yarrow and Co., Ld

Steam Separators
Holden and Brooke, Ld
Lancaster and Tonge, Ld

Steam Shovels
Bucyrus Company

Steam Traps
Bailey, W. H., and Co., Ld
Hobdell, Way and Co., Ld
Lancaster and Tonge, Ld
Royles Ld
Whiteley, Wm., & Sons, Ld

Steel
Allen, Edgar and Co., Ld
Armstrong, Whitworth and Co
Beardmore, W., and Co
Beckett, A., and Sons, Ld
Brit. Westinghouse Electric Co
Brown, Bayley's Steel Works
Cammell Laird and Co., Ld
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Mr. Justice Parker.
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